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Procedures for Investigating and Reporting Human Factors and Fatigue Contributions to Marine Casualties

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16. Abstract

Obtaining a better understanding of how human factors contribute to marine casualties is a key to improving marine safety. Fatigue is of special concern. This report documents research which was successful at improving the Coast Guard's methods for investigating and reporting the incidence of fatigue in marine accidents.

Two hundred and seventy-nine marine casualties (vessel casualties and personnel injuries) were investigated and analyzed using the new procedures. Analysis of potential indicators of fatigue identified three factors that could be combined to calculate a *Fatigue Index* score for casualty cases: (1) the number of fatigue symptoms reported by the mariner; (2) the number of hours worked in the 24 hours prior to the casualty; and (3) the number of hours slept in the 24 hours prior to the casualty. Application of the *Fatigue Index* score showed that fatigue was a contributing factor in 16% of critical vessel casualties and 33% of personnel injuries, making fatigue a significant causal factor in marine casualties.

Further analysis of the fatigue data identified a number of operational conditions which appear to distinguish fatigue-related casualties from casualties caused by other factors. Application of these investigation procedures to a larger sample of casualties is recommended in order to identify reliably what operational factors and what industry segments appear to be related to higher rates of fatigue-related casualties.

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METRIC CONVERSION FACTORS

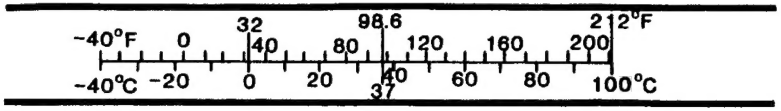
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	* 2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (WEIGHT)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (EXACT)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly).

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (WEIGHT)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (EXACT)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Executive Summary

This project is part of an ongoing program aimed at identifying strategies for improving current Coast Guard procedures for investigating, reporting, and analyzing human contributions to marine casualties. The focus of this project was the contribution of fatigue in vessel and personnel injury casualties. The project had four objectives:

- Develop and implement procedures for investigating and reporting human factors and fatigue contributions to marine casualties;
- Evaluate the usability of the developed procedures in the field;
- Evaluate the value of the resulting casualty statistics; and
- Determine the applicability of the procedures and general approach for broader use within the Coast Guard.

This project was successful in developing and implementing procedures for investigating and reporting information directly relevant to the contribution of fatigue in marine casualties. Four Marine Safety Offices (MSOs) participated in the project, supporting the development of procedures, investigating and reporting marine casualties, and providing detailed feedback on the usability of the procedures. The investigation and reporting procedures were designed to collect detailed information regarding conditions contributing to fatigue and symptoms of mariner fatigue prior to the casualty.

We analyzed 279 personnel injuries and critical vessel casualties (casualties in which there was significant damage to the vessel or property or in which the safety of the crew was at risk). Analysis of potential indicators of fatigue identified three factors that could be combined to calculate a *Fatigue Index* score for casualty cases: (1) the number of fatigue symptoms reported by the mariner; (2) the number of hours worked in the 24 hours prior to the casualty; and (3) the number of hours slept in the 24 hours prior to the casualty. Casualties with Fatigue Index scores greater than an empirically established cut-off point were identified as those likely to have a fatigue contribution. Eighty percent of the cases with high Fatigue Index scores had been judged to have involved fatigue by an IO, the involved mariner, or both. The Fatigue Index procedure is currently based on a small sample of casualties. Analysis of a larger sample of casualties could yield an easy-to-use investigation technique for identifying casualties that are likely to have a fatigue contribution.

Application of the *Fatigue Index* procedure resulted in estimates that fatigue was a contributor to 16 percent of the critical vessel casualties and 33 percent of the personnel injury casualties. These estimates are substantially greater than the estimates of 1.2 percent and 1.3 percent for vessel casualties and personnel injuries, respectively, that were made on the basis of 1993 MINMOD data analyses. This finding indicates that fatigue is a much more significant problem in marine casualties than previously indicated by Coast Guard casualty investigation statistics.

Further analysis of the fatigue data identified a number of conditions that significantly contribute to fatigue. Among the critical vessel casualties, the contributors to fatigue were:

- Number of consecutive days worked prior to the casualty;
- Number of days worked in the 30 days prior to the casualty;
- Hours on duty prior to the casualty;
- Hours worked in the past 24, 48, and 72 hours prior to the casualty;
- Change from the normal working schedule on the day of the casualty; and
- Absence of company or union policies governing work hours.

A subset of these factors was also found to significantly contribute to fatigue in the personnel injury casualties. Further analysis of the casualty data revealed that several industry segments had much higher rates of casualties with fatigue contributions than other segments. The present findings regarding the working conditions contributing to fatigue and the industry segments with high rates of fatigue involvement are promising. However, these results are based on a small sample of casualties. Application of the procedures used in this study to a much larger number of casualties would be required to reliably determine the working conditions that contribute to fatigue in marine casualties and identify industry segments with significantly higher rates of fatigue-related casualties.

Recommendations

Apply the fatigue investigation and reporting procedures to all critical vessel and personnel casualties investigated by the Coast Guard for a one-year period. We recommend that revised versions of the procedures used in this study be applied in the investigation and reporting of all critical vessel and personnel casualties under the Coast Guard's purview for a period of one year. Implementation of these procedures should involve revised training sessions, streamlined investigation procedures and instructions, the review of all reports by human factors specialists, and a quality assurance process that provides feedback to IOs regarding additional actions required on specific cases. The resulting data should prove adequate to identify industry segments that require attention to reduce the rates of fatigue-related casualties. The data should also support the identification of working conditions that are contributing to fatigue-related casualties. In addition, these data should provide an adequate basis for developing an easy-to-use investigation screening procedure for identifying casualties that are likely to have a fatigue contribution.

Support the conduct of additional human factors investigation and reporting pilot studies. We recommend continued support of additional human factors investigation and reporting pilot studies. The approach and methods developed in this study can be applied directly in the research of other human factors contributions to marine casualties. Potential topics of study include working environment hazards, equipment usability, aids to navigation, communications and coordination, and training. Continued Headquarters support of these pilot studies will ensure that procedures will be field tested, assessed, and refined prior to operational implementation.

Conclusion

This research and development project was successful in developing and implementing procedures for investigating and reporting general human factors and fatigue contributions to marine casualties. This pilot study demonstrated that the procedures were usable in the field and that data from a broader field application could provide new insights into the causes and symptoms of fatigue-related marine casualties. The next step in the investigation of fatigue is to make a transition from research and development to operational implementation, to obtain the casualty data necessary for definitive answers to the issues addressed in this pilot study. At the same time, additional research and development pilot studies should be initiated to investigate the role of other human factors in marine casualties. Continued effort in these areas holds promise for reducing future rates of human-related marine casualties.

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1. INTRODUCTION

Estimates of the proportion of casualties attributable to human factors range between 50 and 90 percent. This broad range of estimates belies the highly divergent approaches among investigators, analysts, and researchers of marine casualties across the industry. There is very limited agreement on either the magnitude of this problem or the specific root causes leading to these casualties. Obtaining a better understanding of these human factors contributions is a key to improving safety. However, this will require fundamental improvements in two areas of marine casualty investigation and reporting. First, more consistent procedures for investigating and reporting human factors contributions to marine casualties are required so that valid and reliable casualty data are available for analysis. Second, common definitions of human factors contributions to casualties are required to provide a common basis for the analysis of casualty data.

Emphasis on investigation and analysis of human-related causes of marine casualties within the U.S. Coast Guard (USCG) has increased in recent years. To increase the consistency and value of the USCG's investigation and analysis of human-related casualties, a human factors taxonomy was introduced into the Marine Investigations Module (MINMOD) of the Marine Safety Information System (MSIS) in 1992. Recent assessments have been conducted by both the USCG Research and Development Center[1,2] and USCG Headquarters offices[3,4] to identify areas for further improvement in the Coast Guard's investigation and reporting of human factors in marine casualties. A common finding among all of these assessments is that the current investigation and reporting procedures employed by Investigating Officers (IOs) at the USCG's Marine Safety Offices (MSOs) could be substantively updated to improve the validity, reliability, and value of the resulting casualty data. The research presented in this report was conducted to develop and assess procedural improvements that can be implemented at MSOs to update this process.

1.1 The Current USCG Casualty Investigation and Reporting Process

Investigating and reporting marine casualties is the responsibility of approximately 160 full-time, 50 part-time, and 70 reservist Investigating Officers working out of the USCG's MSOs. Most full-time IOs are Coast Guard military personnel. The majority of these IOs have completed a three-week Investigation Department Course taught at the USCG Reserve Training Center in Yorktown, Virginia, but few of them have had any formal training in the role of human factors in marine casualties. The average time on the job of an Investigating Officer is 12 months[2], and few IOs have had any investigation experience prior to their assignment to an MSO.

Investigating Officers are assigned casualty cases that are identified through a *Report of Accident, Injury, or Death* (CG 2692), communications with other USCG departments, or via the media. According to an earlier study, an IO typically opens approximately three cases per week, with the investigation load varying between different MSOs and Investigating Officers.[2] The majority of an IO's day is spent

investigating casualties and entering the results of these investigations into the MINMOD system. There is typically a 2:1 ratio of time spent on investigation and MINMOD data entry, respectively. Other duties include collateral responsibilities, training, and participating in Personal Action hearings. Investigations are predominantly conducted via telephone at most MSOs; however, a few MSOs typically send a staff member to the vessel or scene of the casualty whenever possible.

An assessment conducted by Rothblum[1] found that human factors data entered into the MINMOD at two MSOs were neither correct nor complete. As a follow-up to this initial effort, Byers, Hill, and Rothblum conducted a more comprehensive assessment at six MSOs.[2] These researchers determined that the accuracy, reliability, and completeness of human factors data in the MINMOD were lacking as a result of several factors, including: (1) unclear policy regarding whether to collect human factors data; (2) insufficient training of Investigating Officers in the role of human factors in marine casualties; (3) obstacles to conducting timely, on-scene investigations; (4) the use of a confusing and poorly structured taxonomy of human factors contributions to casualties; and (5) a MINMOD computer interface that is time-consuming and difficult to use.

Subsequent to these assessments, Headquarters initiated two significant studies to improve the USCG's ability to prevent human-related marine casualties: (1) The Prevention Through People (PTP) Quality Action Team (QAT) study[3] and the Marine Safety Investigation Process QAT study.[4] The PTP QAT found that sufficient information is currently not available to assess the extent and nature of human factors contributions to casualties. Specific problems identified by the PTP QAT include inadequate human error causal data and a lack of any standard human error taxonomy or root cause investigation method. The QAT cited two of the major reasons for the persistence of marine casualties: (1) specific human errors that cause casualties are not identified, and (2) high-risk operations are not identified or systematically analyzed. The QAT identified a strategy for reducing marine casualties using four components: (1) broad collaboration between the USCG and industry; (2) risk management tools; (3) techniques by the Coast Guard to detect, assess, and prevent human error as part of boardings, examinations, and inspections; and (4) improvement of marine casualty investigation methods, data collection, analysis, and feedback.

The Marine Safety Investigation Process QAT had the more focused objective of identifying areas for improvements in marine casualty investigation, reporting, and analysis. This QAT also identified limitations in the value of the current MINMOD database to support human factors investigation and analysis, and recommended updating the marine casualty investigation process and providing human factors training to Investigating Officers. Another recommendation of the Marine Safety Investigation Process QAT was aimed at providing more time and focus to the investigation of critical marine casualties by reducing or eliminating the investigation of minor casualties.

1.2 Project Approach and Scope

The overall goal of this study was to develop and test investigation and reporting procedures that will support Investigating Officers in the complete, accurate, and reliable identification of human factors contributions in marine casualties. The basic approach was that of a small-scale (pilot) implementation and assessment study. Our strategy in developing and implementing these investigation and reporting procedures was to:

- Limit IOs' investigation and reporting to well-defined data;
- Provide participating IOs training in the use of the procedures; and
- Employ stand-alone reporting forms that would not require access to the MINMOD database.

Our basic approach to assessing the developed procedures was two-fold. First, the ease-of-use and practicality of the procedures were assessed by obtaining feedback from Investigating Officers. Second, we directly assessed the value of the resultant casualty data.

To maintain a manageable project scope, we set several limits on the type and number of casualty reports obtained and analyzed. First, rather than addressing the full spectrum of marine casualties, the scope of this project was limited to vessel and personnel injury casualties. Second, because human factors contributions to marine casualties represent a very broad spectrum of causes, the project scope focused on one specific human factors topic. The topic of fatigue was selected due to its apparent prevalence in the maritime industry and recent international interest in this area. Third, we wanted our sample of casualties to represent a broad geographical and industrial range. Through our review of MINMOD casualty statistics, this led to our selection of four MSOs, two from the West Coast and one each from the Gulf of Mexico and the East Coast. Finally, based on our preliminary estimates of the prevalence of human factors and fatigue contributions to casualties, we determined that we would require approximately 500 cases to statistically assess the value of the casualty data. This led to our decision to collect all vessel and personnel injury cases from our targeted MSOs for a period of six months.

1.3 Project Objectives

Given the overall goal and approach of this study, four primary objectives were defined. The first project objective was to *develop and implement procedures for investigating and reporting human factors and fatigue contributions to marine casualties.* Investigation and reporting procedures were developed that could be used by IOs during the normal course of their duties. Stand-alone reporting forms and instructions were developed. Implementation included IO training, early assessment and revisions of the forms and instructions, and periodic feedback to IOs.

The second project objective was to e*valuate the usability of the developed procedures in the field.* Investigating Officers provided direct feedback to us regarding their experiences in using the investigation procedures and reporting forms. An extensive protocol for soliciting feedback from IOs

regarding their experience in using the procedures was developed and administered to IOs at the conclusion of their participation.

The third project objective was to *evaluate the value of the casualty statistics.* Basic issues addressed in our assessment included the value of the data in:

- Reliably and validly identifying marine casualties with a direct human factors contribution;
- Identifying casualty types and industry segments associated with marine casualties with a human factors contribution;
- Specifying indicators that can be used reliably to identify cases that are likely to have a fatigue contribution;
- Estimating the prevalence of fatigue as a contributor to marine casualties;
- Identifying specific working conditions that contribute to fatigue in marine casualties; and
- Identifying casualty types and industry segments associated with marine casualties with a fatigue contribution.

The fourth project objective was to *determine the applicability of the procedures and general approach for broader use within the Coast Guard.* This last objective required us to consider the developed procedures in the context of the Coast Guard's broader objective of improving human factors investigation, reporting, and analysis procedures, and to recommend initiatives that could help in meeting this objective.

2. METHODOLOGY

2.1 Methodology Overview

Development and implementation of the methodology used in this study began with the initial development of the investigation and reporting procedures, forms, and instructions to be used by the Investigating Officers. A total of 42 IOs from four MSOs supported this project by investigating and reporting marine casualties in accordance with these procedures and providing the project team feedback on the developed procedures. Fifteen IOs participated in all phases of the project: initial training, the six-month investigation period, the subsequent three-month period of report completion, and a final assessment of procedures. The remaining 30 Investigating Officers rotated in or out of their IO billets during the project, or had limited involvement in the project, due to their part-time or reservist status. The six-month investigation and reporting period began on July 1, 1995 and continued through December 31, 1995. During the third month of the investigation and reporting period, an initial assessment of procedures was conducted at the MSOs. The final assessment of procedures was conducted at MSOs in March 1996.

2.2 Investigation and Reporting Process

The initial step in the development of the investigation and reporting procedures was to review the current practices of several investigative agencies to obtain an understanding of their human factors investigation process, the nature of the human factors information collected, and the type of analyses performed on the human factors data contained in their databases.[5,6,7] This review of various agencies' approaches to the investigation and reporting of human factors led to the development of a simple two-step procedure consisting of (1) an initial human factors screening followed by (2) a fatigue investigation of human factors cases. Separate reporting forms were developed for the human factors screening step (Form A) and the fatigue investigation step (Form B). These forms went through two revisions. Revision 2 was prepared in response to initial difficulties observed in IO completion of the forms. Revision 3 of Forms A and B were prepared following the initial assessment of procedures (see Section 2.5). Copies of the final versions of Forms A and B (Revision 3) and the instructions can be found in Appendix A.

The initial step of the investigation was conducted to identify cases with a direct human factors contribution to the casualty. In this step, IOs were to determine if there were any individuals who, through their decisions, actions, or inactions, contributed directly to the outcome or severity of the casualty. A contributing individual could be identified as the mariner who committed the last action or decision in the accident sequence, the person who was injured in a personnel casualty, or the person in charge of the vessel or supervising the actions of others. However, this person's decisions, actions, or inactions had to be directly linked to the immediate series of events leading to the casualty. Latent errors, ones contributing to the operational setting but not directly linked to the casualty, were not

considered in this investigation process. If no individuals were identified, it was assumed that the casualty did not have any direct human factors contribution. In such cases, there was no need to pursue the investigation of fatigue-related factors and the IOs completed Form A only. However, if one or more contributing individuals were identified, the second step was to investigate specific fatigue elements and complete Form B as well.

The design of the fatigue investigation and reporting procedures required an agreed-upon set of criteria that would provide evidence regarding conditions that led to fatigue, or specific actions that could be attributed to a fatigue response. Thus, in the design of the reporting forms, it was necessary to consider both a general definition of fatigue as well as the conditions which lead to fatigue and the actions associated with fatigue in the marine environment. Fatigue is typically viewed as a general response to various forms of stress, resulting in a broad range of subjective indicators and performance decrements.[8] Figure 1 presents a summary of the factors contributing to fatigue and the performance consequences of fatigue.

FACTORS CONTRIBUTING TO FATIGUE

Job Role/Life Stress
- Time onboard
- Crew competency
- Time on assignment
- Pressure for risk-taking behaviors
- Task complexity

Sleep-Rest Cycle Disruption
- Length & quality of sleep
- Normal work/rest cycle
- Recent changes in normal work cycle
- Hours worked in past 24, 48, 72 hours

Physical Stress
- General physical condition
- Illness
- Adequacy of meals
- Hours worked past 30 days

Environmental Stress
- Weather
- Noise/vibration level
- Severe ship motion

PERFORMANCE CONSEQUENCES OF FATIGUE

Cognitive Response Shift
- Difficulty in mental arithmetic
- Difficulty in code recognition

Memory Problem
- Difficulty in retention
- Difficulty in recall of new information

Time on Task Decrement
- Generally slow response to unexpected events

Optimum Response Shift
- Reduced fine motor performance

Lapse
- Periods of very delayed responding
- Periods of no responding

False Response
- Increased reporting and response to targets not requiring response

Figure 1. Factors contributing to fatigue and performance consequences of fatigue

This set of contributing factors and performance consequences was incorporated into casualty reporting Form B, as shown in Figure 2. The purpose of Form B is to collect data that will determine whether fatigue was a contributing factor to the casualty. Form B has three main sections: (1) a description of the casualty day and activities of the mariner, (2) a summary of the mariner's work/rest schedule, and (3) a section for the IO to comment on the mariner's actions and truthfulness of the information provided. This information was to be gathered for all casualties in which a human factors contribution was identified.

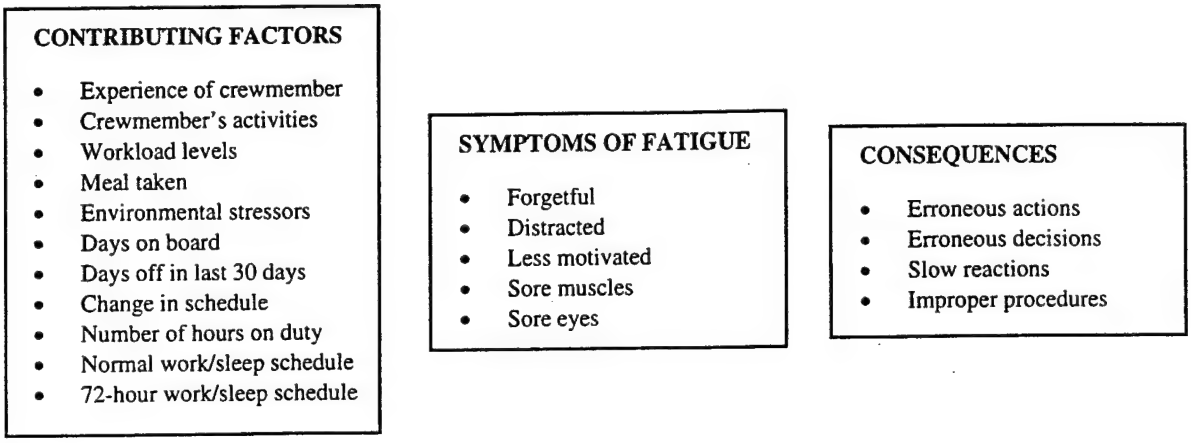

Figure 2. Set of contributing factors, symptoms, and performance consequences used in the fatigue-related data collection form (Form B).

2.3 *Investigating Officer Training*

Investigating Officers at each participating MSO received one day of initial training on the use of the investigating and reporting procedures and forms. Training was conducted to:

- Introduce the project goals and objectives;
- Develop a general understanding of some basic human factors and fatigue concepts; and
- Familiarize IOs with the investigation and reporting procedures used in this project.

Given the training's short duration and the need to ensure IOs' proficiency with the investigation and reporting procedures, the amount of time spent on human factors concepts was limited. A greater proportion of time was spent introducing the concepts of fatigue, factors contributing to fatigue, and the performance decrements associated with fatigue.

The next training activity introduced the investigation steps necessary to identify human factors and fatigue as contributors to a marine casualty. The human factors screening process and its associated concepts were also described to ensure that IOs understood this critical phase of the investigation process. Investigation and reporting forms were then presented in detail. The instructors introduced each form, discussed its purpose, and described each component of the form.

Experience in using the forms was provided through a role-playing activity. One of the IOs volunteered to act as the investigator while the instructor played the role of a mariner involved in the casualty. The IO had to interview the mariner to obtain the information necessary to complete Forms A and B. A debriefing followed, identifying the difficulties and the effective techniques used to gather the human factors and fatigue information. For future reference, each IO received copies of both completed and blank forms, a set of detailed instructions for filling out Forms A and B, and photocopies of the slides used in the training class. A copy of the slides used during the training course can be found in Appendix B.

At least 20 investigators attended the initial training. Those who missed the initial training received an abbreviated training session held later. The content of the abbreviated training was based directly on the initial training provided in June and July. However, the role-playing activity was replaced by a walk-through of the completed forms. Unfortunately, the project team was not able to train many of the reservists. However, one of the participating MSOs conducted a short in-house training session for its reservists using the material provided during the initial training.

2.4 Review of Reports by Research Staff

Investigating Officers were to fill out Form A for all vessel casualties and personnel injuries investigated between July 1, 1995, and December 31, 1995. Form B was to be filled out for all cases in which a direct human factors contribution was identified in Form A. These forms, along with supporting materials (CG 2692 and selected parts of the MINMOD report) were sent to Battelle for review and data entry. Each report was reviewed by either one or two human factors researchers for three specific attributes: (1) completeness of the human factors information, (2) accuracy of the human factors judgment, and (3) completeness of the fatigue information. To judge the completeness of the human factors information, Battelle staff read CG 2692 and the MINMOD reports, focusing mainly on the narrative portions. The criterion used to judge completeness was that, having read the casualty report, the human factors researcher(s) had a good understanding of the nature of the casualty and its sequence of events. If Battelle staff judged that they did not have sufficient information to make an assessment, they requested additional data from the IO.

To evaluate the accuracy of an IO's human factors judgment, the following data were considered: (1) the type of casualty, (2) the sequence of events, and (3) if applicable, the mariner's activities. Initially, the two human factors researchers reviewed all the casualty cases received. Just prior to the initial evaluation visit, Battelle staff compared the accuracy of human factors judgments between the researchers and the IOs. Using a random selection of 25 cases, each human factors researcher read the CG 2692 and MINMOD narrative then made an independent judgment of whether human factors were directly involved. Agreement between researchers was obtained for 96 percent of these cases, while the agreement between each researcher and IOs was obtained for between 64 and 68 percent of the cases.

Given the relatively high agreement ratios between the two human factors researchers, it was decided that all casualties would be reviewed initially by one of them, and that in cases of doubt or poorly-defined cases, both researchers would review the case and make a joint human factors judgment. If a casualty case was judged by the research staff as having a direct human factors contribution, but not so judged by the IO, the IO was contacted, the case was discussed, Form A was amended, and the IO was asked to complete Form B.

Battelle staff also reviewed each casualty report for the completeness of fatigue information. It was anticipated that some questions would not be answered either because the mariner had forgotten, refused to answer, or because the item did not apply to the circumstances of the casualty. However, in other

instances, the human factors researcher could not determine why a question was not answered. In those instances, as well as when the question was incorrectly answered (e.g., improper format, missing some elements), the human factors researcher contacted the IO either to request the missing information or to obtain clarification.

Throughout the entire data collection period, a summary of cases received, comments, and questions was maintained. These summary sheets were periodically sent to each participating MSO for the IOs to review. A newsletter was prepared and sent to the participating MSOs twice during the investigation and reporting period to maintain the IOs' interest and support of the project by giving them feedback on the project progress. Copies of the newsletters are provided in Appendix C.

2.5 Initial Procedure Assessment

An initial on-site procedure assessment was completed approximately three months into the investigation and reporting period. The purpose of this assessment was to:

- Review the investigation and reporting process with the IOs to identify issues of concern;
- Obtain suggestions on how to improve or modify the process and the reporting forms; and
- Ensure that training had produced uniform investigating and reporting procedures.

The one-day procedure assessment was conducted at all MSOs and reached 19 investigators. An abbreviated training session took place in the morning. The afternoon was devoted to a group discussion on the adequacy of the investigation process and reporting forms, and individual meetings with each IO to review ongoing and completed casualty cases.

Prior to the initial procedure assessment, Battelle received 65 casualty cases with completed forms. A review of these cases provided the basis for discussion topics during the initial procedure assessment. The group discussion topics addressed the investigation process, gathering information, reporting the information on either one of the forms, and potential changes to the forms. Finally, individual discussions were conducted to review specific casualty cases for which Battelle staff had identified issues of concern and to evaluate each IO's understanding of the investigation and reporting procedures. Based on the information gathered during this initial assessment, Forms A and B were revised to their final format.

2.6 Final Procedure Assessment

Approximately three months after the end of the data collection period, we again visited each participating MSO to obtain the IOs' feedback about the process, which lasted approximately one day. The day started with a presentation of some preliminary findings from Forms A and B. IOs were then asked to complete a survey evaluating the training sessions and support materials, the investigation and reporting forms, and the benefits and disadvantages of this project. They were also asked to provide recommendations for improvements to the entire process. A copy of the assessment survey can be found

in Appendix D. Following completion of the survey, IOs participated in a group discussion of these issues.

3. FINDINGS

This section presents our findings pertinent to the usability of the developed procedures in the field and the value of the casualty statistics.

3.1 Assessment of Investigation and Reporting Process

Our assessment of the investigation and reporting process addressed a wide range of issues. Most of our data were obtained during the final procedure assessment. A total of 25 investigating officers participated in this assessment—3 senior IOs, 19 full-time or part-time IOs, and 4 reservists or civilians. Appendix D provides detailed survey results. This section presents the findings pertinent to five issues:

- time demands on IOs;
- value of training;
- usability of the investigation and reporting procedures;
- ability to collect valid fatigue information; and
- value of feedback to MSOs.

3.1.1 Time Demands on Investigating Officers

As part of the reporting process, IOs were asked to indicate the time spent investigating and completing Forms A and B, in addition to their normal activities. Investigating Officer's inputs were used to estimate the additional time required for the procedures used in this study by calculating the medians (50^{th} percentiles) for the IOs' responses, shown in Figure 3. For the 188 cases in which there was no direct human factors contribution, the median investigation time was 19 minutes and median form completion time was 10 minutes, for a total of 29 minutes. For the 209 cases with a direct human factors contribution, the median investigation time was 25 minutes and form completion time was 15 minutes, for a total of 40 minutes. Across all 397 cases, the median investigation time was 20 minutes and form completion time was 12 minutes, for a total of 32 minutes. Thus, our best estimate of the additional time associated with the procedures used in this study is 32 minutes per case.

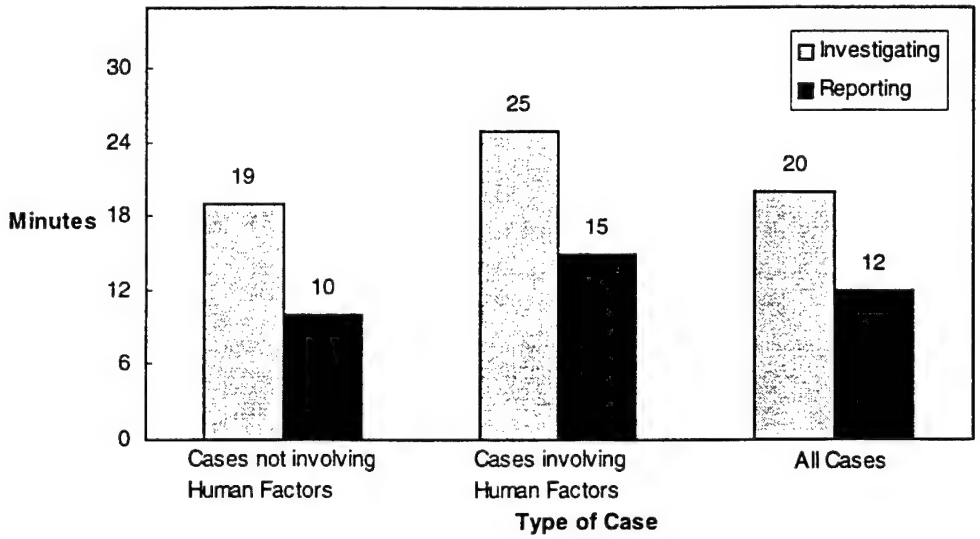

Figure 3. Median estimated time for casualty case investigating and reporting.

3.1.2 Value of Training

IOs were asked to rate the value of the training on a scale of 1 (poor) to 5 (excellent) on four different dimensions: (1) explaining the purpose of the forms, (2) describing what information to collect, (3) providing instructions on how to complete the forms, and (4) preparing IOs in their new role. Of the 25 people surveyed, 16 indicated they had taken part in the initial full-day training session. Average ratings for each of the four areas ranged between 3.8 and 4.1, suggesting that the initial training was highly valued by all those who received it. Among those who could not attend the initial full-day training session, five indicated that they received the half-day training provided by project staff. Their ratings of this training session, using the above criteria, were about the same as the ratings for initial training, with average ratings ranging between 4.0 and 4.4. Four IOs did not attend either training session, and were trained by their co-workers or supervisors. Their average ratings of that training, using the same criteria as above, were slightly lower, ranging between 3.5 and 4.0. These findings suggest that a one-half day training session, augmented by a training video for refresher training could provide an effective and consistent means of training.

3.1.3 Usability of the Investigation and Reporting Procedures

The usability of materials supporting the investigation and reporting procedures was assessed for: (1) the instructions to complete the forms, (2) Form A, and (3) Form B. Although all respondents received a copy of the instructions, its use varied. IOs used the instructions less often during the investigation and more often while filling out the forms. Thirty-nine percent of the IOs referred to the instructions at least half of the time during investigations, while 61 percent referred to the instructions at least half of the time while filling out Forms A and B. When asked to rate the instructions on their ease of use and value in the

investigating and reporting process, IOs gave them a moderate ratings, with average ratings ranging between 3.2 and 3.3.

Form A received an average rating of 3.8 on a scale of 1 (poor) to 5 (excellent) in regard to its ease of use. Throughout the entire project, IOs frequently commented that Form A was unnecessary since most of the information could be obtained on CG 2692. The IOs generally understood that the duplicate items in Form A reduced overall project resource requirements by eliminating the need to access the MINMOD database. However, when asked to make suggestions for improvements to Form A, 7 of the 15 investigators suggested deleting the items that could be found on CG 2692, indicating their preference for an integrated process.

Form B received ease of use ratings that averaged 2.9, indicating some difficulties in using this form. Of the 24 respondents, eight felt that Form B was incomplete in terms of investigating for fatigue. When asked to suggest improvements to Form B, seven IOs suggested that less detailed information be collected concerning mariners' 72-hour work/rest schedules.

When asked to judge the two-step investigation approach (i.e., determining first whether human factors was directly involved and, if so, collecting fatigue data), 74 percent of the 23 respondents rated it as useful. When rating the value of this approach (procedures and forms) in regard to its benefit to the investigation and reporting of human factors and fatigue-related information, IOs gave it a rating of 3.3 on a scale of 1 (poor) to 5 (excellent). Their suggestions to improve the entire process included consolidating Forms A and B, modifying the format for collecting detailed work/rest schedules, and incorporating some of the elements of Forms A and B into CG 2692 so that mariners could answer these questions directly as part of their reporting process.

3.1.4 Ability to Collect Valid Fatigue Information

Investigators rated their ability to obtain various types of fatigue information from the mariners using a scale that ranged from 1 (never) to 5 (always). The most easily obtained types of fatigue information were the mariner's activity at the time of the casualty, hours on duty at the time of the casualty, the mariner's normal work/sleep schedule, and the mariner's opinion on fatigue involvement in the casualty. More difficult information to collect included whether any work breaks were taken prior to the casualty, the identification of any environmental factors that may have contributed to fatigue, specific physical and mental symptoms of fatigue, and the mariner's ratings of workload, sleep quality, and fatigue level.

Using the same rating scale that ranged from 1 (never) to 5 (always) the investigators rated the accuracy of the various types of fatigue information obtained from mariners. The types of fatigue information rated as most accurate included the mariner's activity at the time of the casualty, the mariner's hours on duty at the time of the casualty, the normal work/sleep schedule of the mariner, and whether any work breaks were taken prior to the casualty. Those rated as least accurate included mariners' specific physical and mental symptoms of fatigue, the identification of any environmental factors that may have contributed to fatigue,

the mariner's detailed 72-hour work/rest schedule prior to the casualty, and the mariner's rating of workload, sleep quality, and fatigue level.

Investigating Officers were also asked to rate the validity of the information received from mariners (Form B, item 28). Of the 96 Form Bs completed, 28 percent received a rating of 5 (extremely true and accurate information) and the average rating was 4.5. Considering all of the input regarding the collection of valid fatigue information, it appears that IOs felt that the mariners typically provided true and accurate information, but that some of the information was more susceptible to forgetfulness.

3.1.5 Value of Feedback to Marine Safety Offices

MSOs received feedback in three different ways: (1) on-site visits and presentations, (2) a newsletter, the "Marine Investigator," and (3) a summary sheet of comments and questions on casualty cases. On-site briefings were always well attended, involving lively discussions of investigation and reporting pitfalls and successes. All assessment survey respondents indicated having received a copy of the newsletter. Their ratings, with averages ranging from 3.4 to 3.8 on scale of 1 (poor) to 5 (excellent) indicated that the newsletter was useful in keeping IOs current with the status of the project, summarizing the latest procedures to use, and answering specific concerns and questions. Overall, we believe that the feedback mechanisms employed in the present study were successful in establishing and maintaining IO involvement in a project that placed additional demands on their time; and the key to the success of the feedback was that it provided ongoing evidence that the efforts of the IOs were directly impacting the analysis of marine casualties.

3.2 Assessment of Casualty Data

During the six-month investigation and reporting period, the four participating MSOs investigated and reported 467 casualty cases to Battelle. In accordance with recent QAT recommendations to limit analyses to meaningful casualties, cases were judged to be out of scope of this study and excluded from analysis if they involved one of the following four types of casualties: (1) allisions with a bridge resulting in no property damage or personnel injury; (2) groundings resulting in no property damage or personnel injury that occurred in locations that represent a frequent and accepted risk of operations; (3) injury to a vessel passenger; and (4) death by natural causes. Using these selection criteria further reduced the set of cases by 70, resulting in a total of 397 cases analyzed in this study.

Figure 4 summarizes how the 397 cases in this study were classified for the purposes of analysis. During the course of receiving and reviewing completed casualty reports, it became apparent that a number of vessel casualty types represented "minor" vessel casualties. For the purposes of this study, 118 vessel casualties were classified as "minor" because they involved limited property damage with no risk to the loss of the vessel or personnel injury. These minor cases were those exclusively involving wake damage, steering failure, machinery or equipment failure, lifesaving equipment failure, structural failure, or

emergency equipment failure. These minor casualties were included in selected preliminary analyses to help increase total sample size, but were excluded from all of the analyses addressing specific issues of human factors and fatigue casualty prevalence and characteristics. Most of the analyses were limited to critical vessel casualties (that is, casualties in which there was significant damage to the vessel or property or in which the safety of the crew was at risk) and to personnel injuries. Figure 4 also indicates that nine cases involved both a critical vessel casualty and a personnel injury. These nine cases were included in the two separate analyses of critical vessel and personnel injury casualties, resulting in totals of 144 casualties analyzed in each of the two groups.

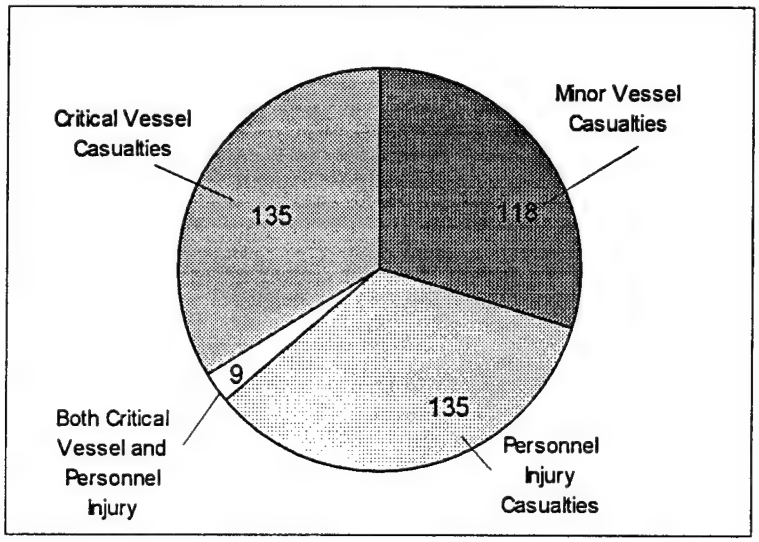

Figure 4. Frequency of marine casualty report types analyzed in the present study.

The remainder of Section 3 presents the findings pertinent to the value of the casualty data. Four separate subsections present findings on the following topics:

- Identification of casualties with direct human factors contribution;
- Characteristics of casualties with direct human factors contribution;
- Identification of casualties with a fatigue contribution; and
- Characteristics of casualties with a fatigue contribution.

3.2.1 Identification of Casualties with Direct Human Factors Contribution

Agreement between the two Battelle human factors researchers on this project was ultimately used to determine direct human factors contributions to casualties during this analysis. This approach was considered acceptably valid, given the training and background of the two Battelle researchers, and their high rate of agreement (96 percent) in classifying casualties. Overall agreement between IOs and project researchers' judgment regarding the presence or absence of a human factors contribution was found to be 84 percent.

Table 1 summarizes the agreement rates between IOs and researchers on the direct contribution of human factors in the 397 casualty cases. The highest level of agreement (93 percent) between IOs and researchers was obtained for *correct rejections*, where both IOs and the research team judged that a given case was not directly related to human factors. A lower level of agreement (75 percent) was obtained for *hits*, where both IOs and the researchers judged a case to be directly related to human factors. The pattern of results in Table 1 represents an overall tendency for IOs to judge fewer cases as directly related to human factors (42 percent), while the researchers judged a greater number of cases as directly related to human factors (53 percent). IOs did not identify 25 percent of the casualty cases that had a direct human factors contribution, which would have substantially altered the estimated level and characterization of direct human factors contributions to casualties, had it not been for the comprehensive review of all cases by the project's human factors researchers.

Table 1. Classification of Direct Human Factors Contribution in Casualties by Investigating Officers and Researchers

		Investigating Officers' Judgment			
		Human Factors	No Human Factors	Totals	
Researchers' Judgment	Human Factors	Hits = 157 Hit Rate = 75%	Misses = 52 Miss Rate = 25%	209	53%
	No Human Factors	False Alarms =13 False Alarm Rate = 7%	Correct Rejections = 175 Corr. Rej. Rate = 93%	188	47%
	Totals	170 (43%)	227 (57%)	397	100%

Table 2 summarizes the rates of direct human factors contributions among the 279 personnel injury and critical vessel casualties. Among the 144 critical vessel casualties (including the nine cases that are both critical vessel and personnel injury), 76 (53 percent) of the cases were classified as having a direct link to human factors. A much higher rate of 91 percent of the 144 cases that involved personnel injury were found to have a direct human factors contribution. Across all personnel injury and vessel casualties, the rate of direct human factors involvement was 71 percent (199 of 279 cases).

Table 2. Rates of Direct Human Factors Contributions to Marine Casualties

	Human Factors		No Human Factors		Totals
Critical Vessel Casualties	68	(50%)	67	(50%)	**135**
Personnel Injuries	123	(91%)	12	(9%)	**135**
Both Critical Vessel and Personnel Injury	8	(89%)	1	(11%)	**9**
Totals	**199**	**(71%)**	**80**	**(29%)**	**279**

3.2.2 Characteristics of Casualties with Direct Human Factors Contribution

A second topic to be addressed in assessing the value of the present casualty data concerns our ability to discriminate between the types of casualties and industry segments involved in the casualties. These topics are discussed in detail in the following paragraphs.

Type of critical vessel casualties with direct human factors contribution. Figure 5 presents the frequency of vessel casualty types with and without a direct link to human factors for the 144 critical vessel casualties identified in this project. This figure indicates that direct human factors links are most prevalent in collisions (81 percent), allisions (69 percent), and groundings (56 percent). In general, these are the types of casualties in which an individual's action, decision, or inaction can be tied directly to inadequate vessel navigation. In contrast, human factors are found to have much lower rates of direct contributions in foundering and sinkings (39 percent), fires (17 percent), and floodings (7 percent). In these latter cases, equipment failure or poor maintenance practices are frequently cited as the cause; which are also a general class of human factors, but one in which the human error may have occurred days or weeks prior to the casualty, and were not classified as having a direct human factors contribution in this study.

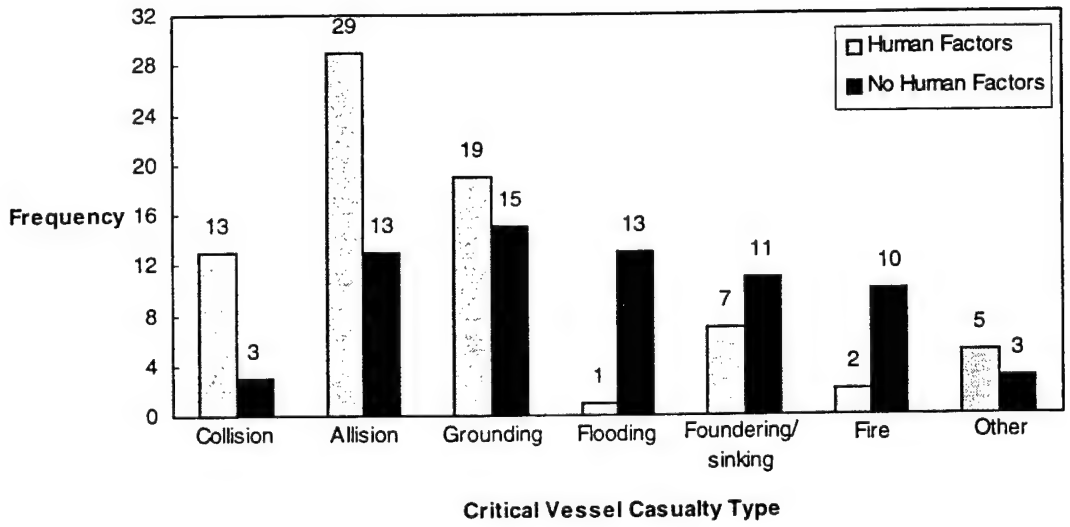

Figure 5. Frequency of critical vessel casualty types with and without a direct human factors contribution.

Industry segments involved in critical vessel casualties with direct human factors contribution. Figure 6 presents the frequency of vessel types involved in vessel casualties with and without a direct human factors contribution for the 144 critical vessel casualties identified in this project. This figure indicates that direct human factors links are markedly higher than the average of 53 percent only among tugs and barges (67 percent), suggesting that closer scrutiny of the casualties in this industry might be worthwhile. The rate of direct human factors contributions was found to be comparable to the average among passenger vessels (55 percent), and markedly lower than the average among freighters (38 percent) and fishing vessels (38 percent). The relatively low rate of direct human factors contributions among the 45 fishing vessel casualties is perhaps the most striking finding here. Closer review of these cases reveals that they include seven floodings, which were all determined not to have a direct human factors contribution. Most of these floodings occurred among unattended vessels secured in the harbor. So, while human error may well have played a role in the floodings, the casualty was not considered to have a direct human factors cause since no mariner was aboard at the time of the flooding. Additionally, 6 of 11 groundings and 9 of 14 founderings or sinkings of fishing vessels were not attributed to a direct human factors contribution. In many of these cases, fishing vessels were caught in unexpected rough weather, which was not classified as a direct human factors link to the casualty.

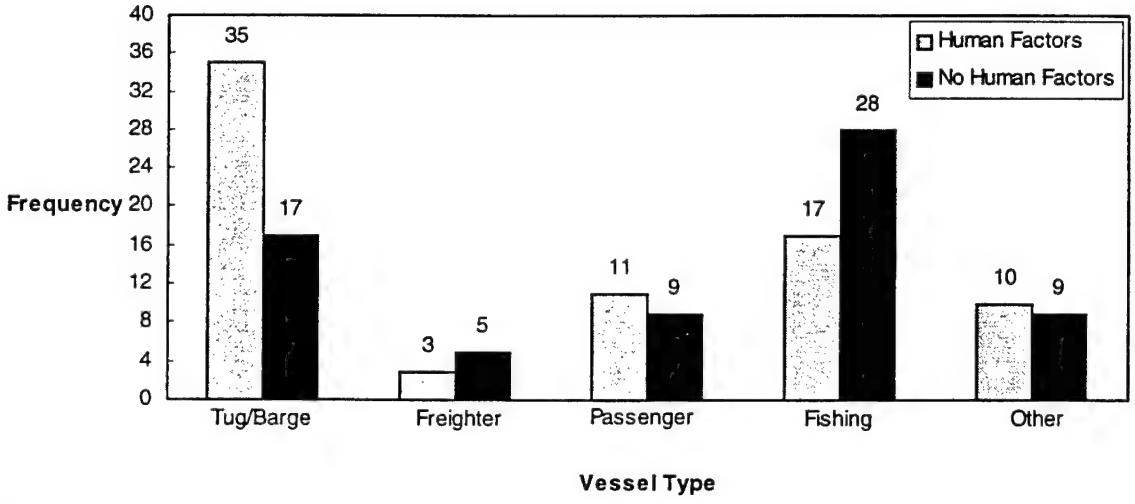

Figure 6. Frequency of vessel types involved in critical vessel casualties with and without a direct human factors contribution.

Types of personnel injury casualties with direct human factors involvement. Figure 7 presents the frequency of personnel injury types with and without a direct link to human factors for the 144 personnel injury casualties identified in this project. This figure indicates a uniformly high rate of direct human factors contributions to these casualties. In general, personnel injuries are identified as frequently involving an unsafe act by the injured person, which would result in a human factors classification in this study. All personnel injuries that resulted in the loss of three or more days of work were investigated and reported in the present study, in accordance with current investigation practice. No further classification of the severity of these casualties was obtained. However, it is noteworthy that 8 of the 144 cases involved a death or presumed death.

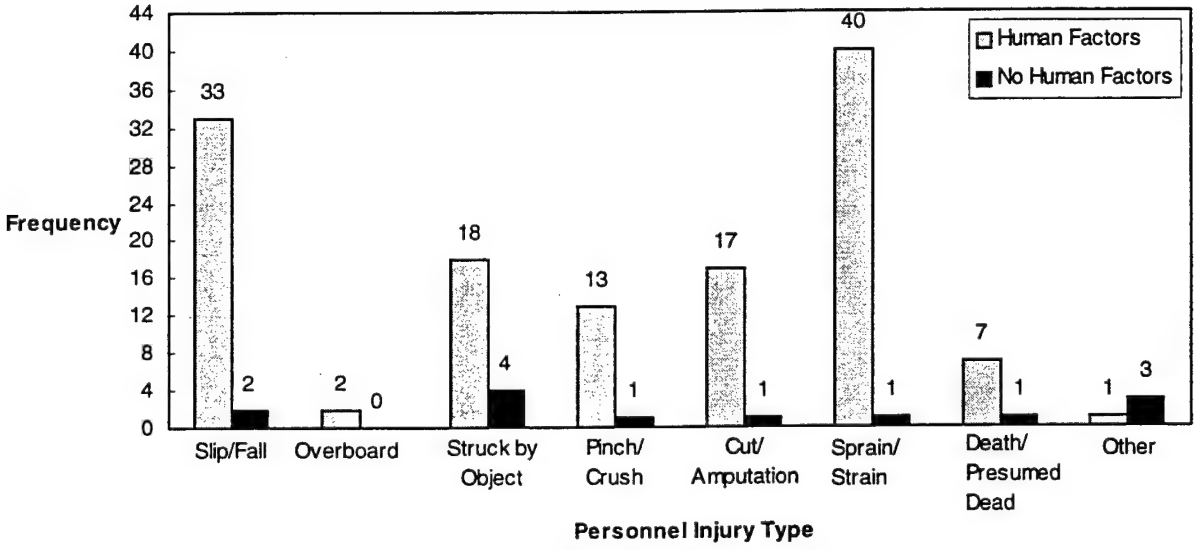

Figure 7. Frequency of personnel injury types with and without a direct human factors contribution.

Industry segments involved in personnel injury casualties with a direct human factors contribution. Figure 8 presents the frequency of vessel types involved in personnel injuries with and without a direct human factors contribution for the 144 personnel injury cases. A uniformly high level of human factors involvement is seen across all vessel types, with the most frequent occurrence of injuries aboard fishing vessels, tugs and barges, processors, and freighters. The data were reviewed in detail to determine the vessel types involved in deaths or presumed deaths with a direct human factors contribution. The deaths and presumed deaths occurred aboard two fishing vessels, an offshore supply vessel (passenger), a stationary oil platform, a mobile drilling unit, a dredge, and an offshore supply vessel under repair in a shipyard. The number of deaths and presumed deaths is too small to draw any firm conclusions; however, it is noteworthy that four of these incidents were linked to the offshore oil industry and two to the fishing industry.

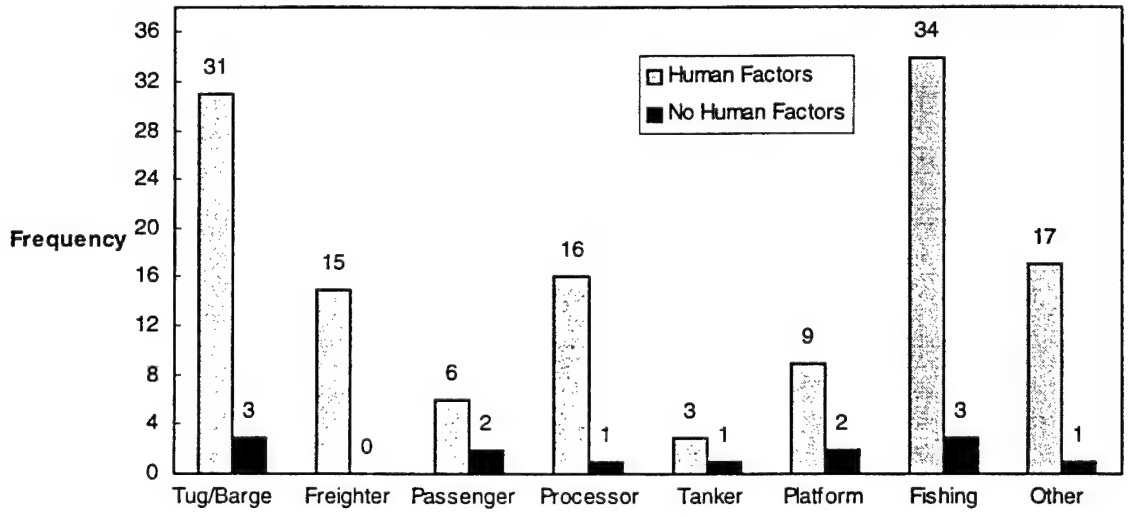

Figure 8. Frequency of vessel types in personnel injury casualties with and without a direct human factors contribution.

3.2.3 Identification of Casualties with a Fatigue Contribution

The next topic in assessing the value of the obtained casualty data concerns the capability to determine whether fatigue was a contributor to the casualty. In this study, the fatigue investigation form (Form B) provides two obvious means of classifying whether casualties had a fatigue contribution or not. Specifically, IOs were to explicitly ask mariners if they thought that fatigue had contributed to a casualty and record the mariner's response. In addition, IOs were to report their personal judgment as to whether

or not fatigue was a contributor to the casualty.[1] The present analyses investigated the relationships between these judgments and objective indicators of fatigue. The resulting *Fatigue Index score* provides an objective and reliable means of classifying cases as to whether fatigue was a contributor to the casualty. Following is a summary of the analyses and findings pertaining to the identification of casualties with a fatigue contribution. A more detailed description of these analyses is provided in Appendix E.

Investigating Officer and mariner identification of fatigue contribution. When asked if they thought that fatigue had contributed to a casualty, mariners indicated that fatigue was a contributor in 17of 98 cases (17 percent). IOs judged that fatigue was a contributor in 21 of a total of 91 cases (23 percent). IOs and mariners agreed on 74 of 86 cases (86 percent). There was a moderately high level of agreement when a mariner had judged that fatigue was a contributor (79 percent), but for those cases judged by IOs to have a fatigue contribution, mariners made the same classification only 55 percent of the time. Across the 23 cases identified by either an IO or mariner as involving fatigue, there was agreement on only 11 (48 percent). Clearly, the two groups were applying different criteria or biases in making a judgment about the role of fatigue in casualties, and mariners were less likely to classify a casualty as having a fatigue contribution.

Fatigue Index Score. A series of analyses was conducted to identify the relationship between the potential indicators of a fatigue contribution in a casualty and the determination, by either the IO or the mariner, that fatigue was or was not a contributor to a casualty. The resulting equation included three factors. Equation 1 provides the resulting *Fatigue Index Equation* for computing a Fatigue Index score for a casualty case, based on the number of fatigue symptoms reported by the mariner, hours worked in the 24 hours preceding the casualty, and hours slept in the 24 hours preceding the casualty.

$$\begin{aligned} \textbf{Fatigue Index Score} = {} & \textbf{[4.39 * (Number of Fatigue Symptoms)]} \\ & \textbf{+ [1.25 * (Hours Worked in Last 24 Hours)]} \\ & \textbf{- [0.93 * (Hours Slept in Last 24 Hours)] + 39.75.} \end{aligned}$$

Equation 1. Equation for computing a Fatigue Index score for a casualty case.

Fatigue Index scores were computed for the 93 cases with data available for the three factors included in the equation. Of these 93 cases, 81 had a judgment made by the IO and/or mariner regarding the contribution of fatigue to the casualty. The distribution of the Fatigue Index scores was adjusted until a cut-off score of 50 resulted in the maximum level of agreement between (a) Investigating Officers and mariners and (b) the Fatigue Index classification, while maintaining equal rates of misses and false alarms. After classifying casualties on the basis of the Fatigue Index cut-off score, 80 percent of the 81

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[1] The request for IO judgment regarding fatigue was implemented following the initial procedure assessment, so this information was not requested for all casualty cases.

cases with a mariner and/or IO fatigue judgment were also classified as having a fatigue contribution using the Fatigue Index procedure.

Estimates of fatigue prevalence in critical vessel and personnel casualties. The Fatigue Index cut-off score was next used to classify all critical vessel and personnel injury casualty cases with sufficient data to determine the contribution of fatigue. Of the 199 critical vessel and personnel injury cases judged to have a direct human factors contribution, 88 cases had adequate Form B data to evaluate the contribution of fatigue using the Fatigue Index procedure, 17 cases had partially completed Form Bs, seven cases involved mariners who refused to cooperate, and 87 cases were those in which the mariner could not be reached. Using the results of applying the Fatigue Index procedure to these 88 cases, the rate of fatigue contributions can be calculated as a product of the human factors and fatigue rates. Figure 9 presents the estimates for the present study, along with estimates obtained from the 1993 MINMOD data. The estimated fatigue contribution rate is 16 percent for critical vessel casualties, 33 percent for personnel injuries, and 23 percent for the combined set of critical vessel and personnel injury casualties.[2] Comparison to fatigue rates calculated for the Coast Guard's MINMOD cases for calendar year 1993 shows that the Coast Guard's estimates of fatigue contribution rates are 1.2 percent for all vessel casualties (rather than only critical vessel casualties) and 1.3 percent for personnel injury cases.

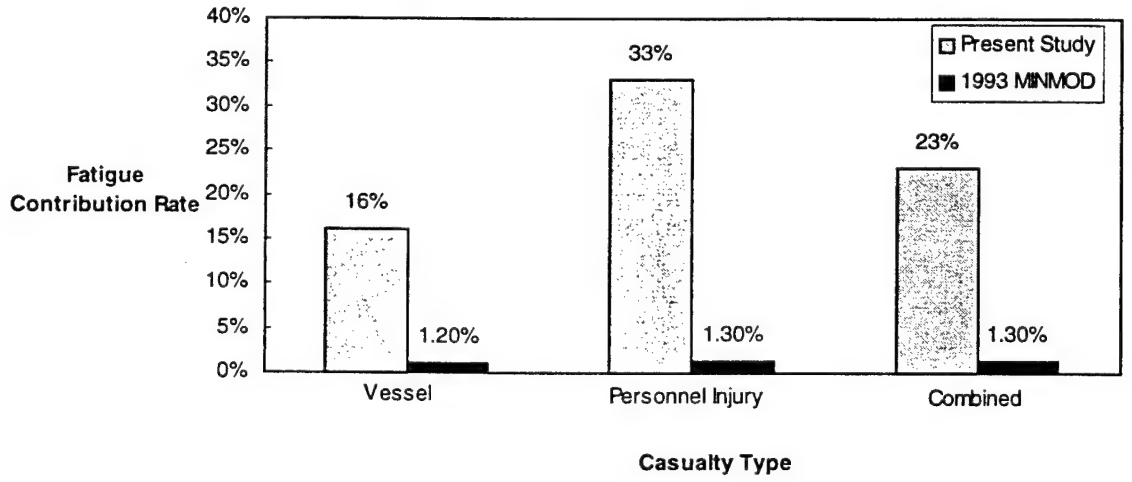

Figure 9. Comparison of estimated rates of fatigue contributions in marine casualties.

Estimates of fatigue rates in the present study are more than ten times greater than those based on the 1993 MINMOD data. Thus, although the present results are preliminary, they point to a significant

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[2] Within critical vessel casualties, the estimated rate of fatigue contribution is 53 percent * 30 percent = 16 percent; for personnel injuries, the estimated fatigue rate is 91 percent * 36 percent = 33 percent. Across all critical vessel and personnel injury casualty cases, the estimated level of fatigue contribution is 71 percent * 33 percent = 23 percent.

fatigue problem that had not been identified using current USCG investigation and reporting procedures. Additionally, it has been shown that the procedures used in the present study can be widely implemented, providing a means of determining the extent of the fatigue problem throughout the USCG's area of responsibility.

3.2.4 Characteristics of Casualties with a Fatigue Contribution

Although the number of casualty cases classified according to their fatigue contribution is limited in this study, the cases were further analyzed to assess the general value of this approach in characterizing casualties with a fatigue contribution. For this assessment, discussed below, results for critical vessel and personnel injury casualties are reviewed separately.

Types of critical vessel casualties with a fatigue contribution. Figure 10 presents the frequency of vessel casualty types with and without a fatigue contribution. Of the total of 40 cases in which fatigue could be evaluated, we see the most prevalent casualty types being allisions, groundings, and collisions. The rate of fatigue across these different vessel casualty types is comparable to the overall human factors rates observed, and points to the broad contribution of fatigue in those types of vessel casualties where an individual's action, inaction, or decision can be tied directly to a casualty.

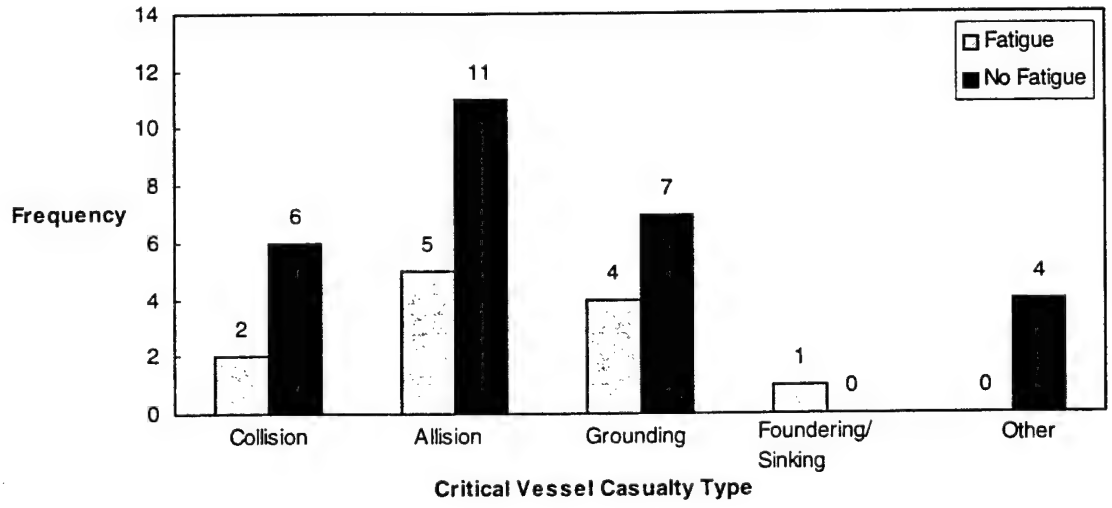

Figure 10. Frequency of critical vessel casualty types with and without a fatigue contribution.

Industry segments involved in critical vessel casualties with a fatigue contribution. Figure 11 presents the frequency of vessel types involved in critical vessel casualties with and without a fatigue contribution. Of the total of 40 cases in which fatigue could be determined, we see fatigue involvement aboard fishing vessels, passenger vessels, and tugs and barges, and other vessel types. A substantially greater number of vessel casualties would need to be investigated, reported, and analyzed using the current methods prior to drawing any conclusions regarding industry segment involvement in fatigue-related casualties.

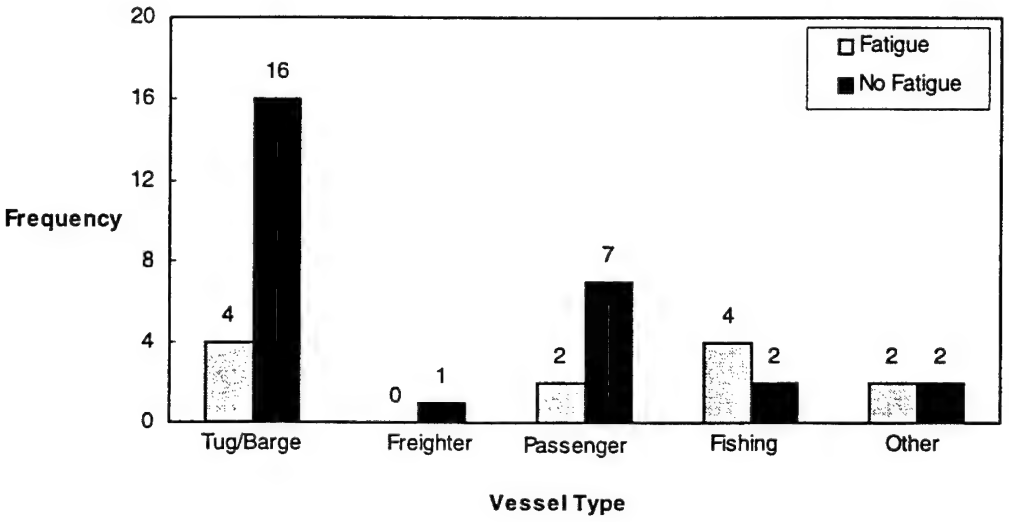

Figure 11. Frequency of vessel types involved in critical vessel casualties with and without a fatigue contribution.

Working conditions contributing to fatigue-related critical vessel casualties. Eighteen factors were analyzed to identify their contribution to fatigue in critical vessel casualties. Appendix F provides a summary of these analyses. Eight separate factors were found to differ significantly with the fatigue classification of critical vessel casualties: (1) the number of consecutive days worked prior to the casualty; (2) the number of days off in the 30 days prior to the casualty; (3) the hours on duty prior to the casualty; (4) the hours worked in the past 24 hours prior to the casualty; (5) the hours worked in the past 48 hours prior to the casualty; (6) the hours worked in the past 72 hours prior to the casualty; (7) the mariner's report that the work schedule during the casualty was different from his normal schedule; and (8) whether there were company or union policies regarding work hours.

Figure 12 compares the average duration of the six factors which involved the reporting of days or hours. Here we see clear differences across all factors between critical vessel casualties with and without an identified fatigue contribution, suggesting that all of these factors contributed to the mariners' fatigue in these casualties. In addition, of the nine cases where the work schedule at the time of the casualty was reported to be different from normal, six (67 percent) were identified as having a fatigue contribution, using the Fatigue Index procedure. Finally, of the 16 cases where there were no company or union policies regarding work limits, eight (50 percent) were identified as having a fatigue contribution. The substantial number of different working conditions identified as contributing to fatigue-related critical vessel casualties provides strong support to the value of these data.

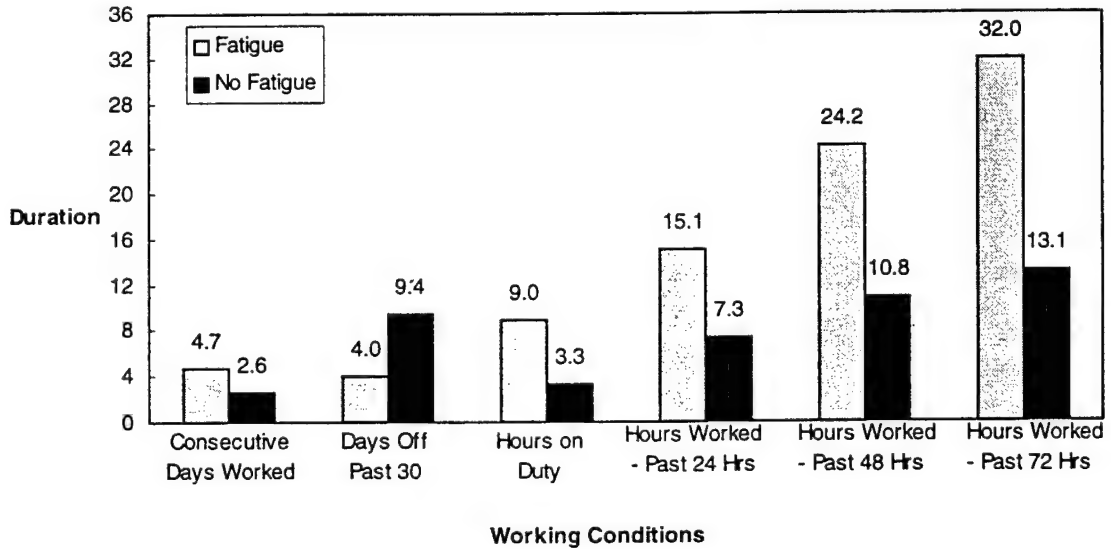

Figure 12. Comparison of working conditions found to significantly contribute to fatigue-related critical vessel casualties.

Types of personnel injuries with a fatigue contribution. Figure 13 presents the frequency of personnel injury types with and without a fatigue contribution. Of the total of 53 cases in which fatigue could be determined using the Fatigue Index procedure, we see the highest frequencies of fatigue in injuries involving slips/falls and sprains/strains. In addition, we see a high rate of fatigue contribution (but low overall frequency due to our small sample) in injuries involving amputations, being struck by objects, and being pinched and crushed. The rate of fatigue across these different personnel injury types appears relatively comparable, with the exception of cuts, and suggests a broad range of fatigue affects in these casualties.

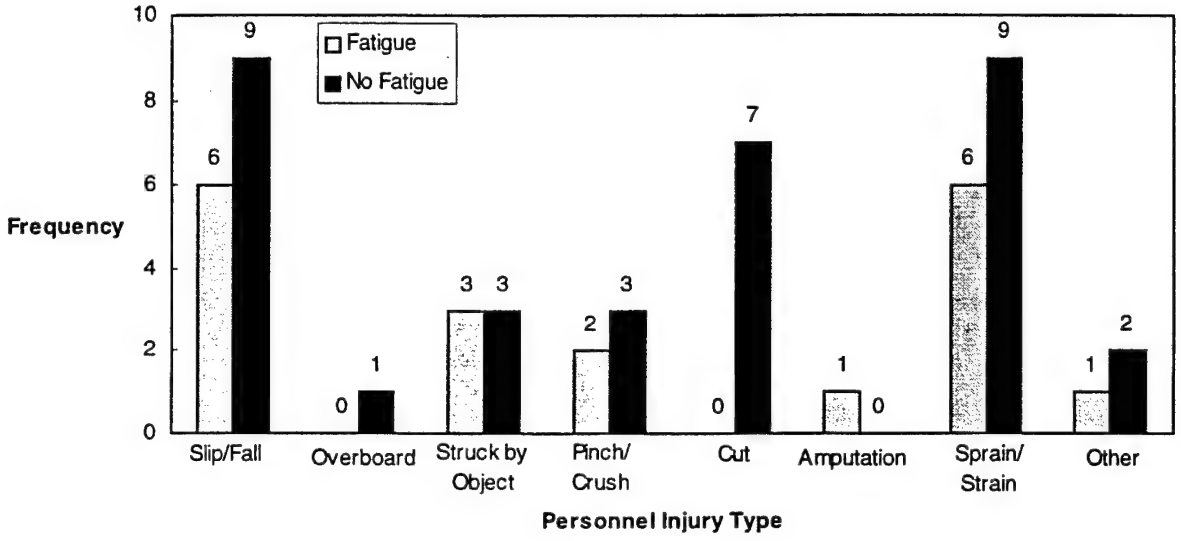

Figure 13. Frequency of personnel injury types with and without a fatigue contribution.

Industry segments involved in personnel injuries with a fatigue contribution. Figure 14 presents the frequency of vessel types involved in personnel injury casualties with and without a fatigue contribution. Of the 19 personnel injury cases that appeared to have a fatigue contribution, fishing vessels, tugs and barges, and fish processors are most frequently represented.

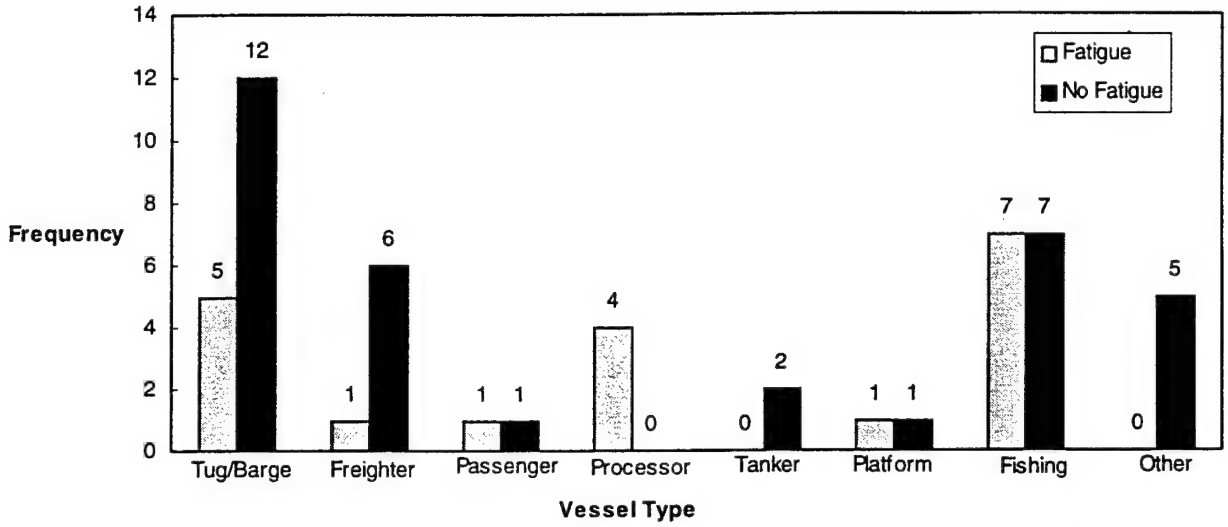

Figure 14. Frequency of vessel types involved in personnel injury casualties with and without a fatigue contribution.

Working conditions contributing to fatigue-related personnel injury casualties. Analysis of potential contributors to fatigue in personnel injury casualties identified four separate factors that were found to differ significantly with the fatigue classification for the cases. Figure 15 compares these four factors. Here we see clear differences between personnel injury cases classified as fatigue or not fatigue on the basis of: (1) the hours on duty prior to the casualty; (2) the hours worked in the past 24 hours prior to the casualty; (3) the hours worked in the past 48 hours prior to the casualty; and (4) the hours worked in the past 72 hours prior to the casualty. We again find strong support for the value of these data, based on our ability to identify working conditions contributing to fatigue-related personnel injuries.

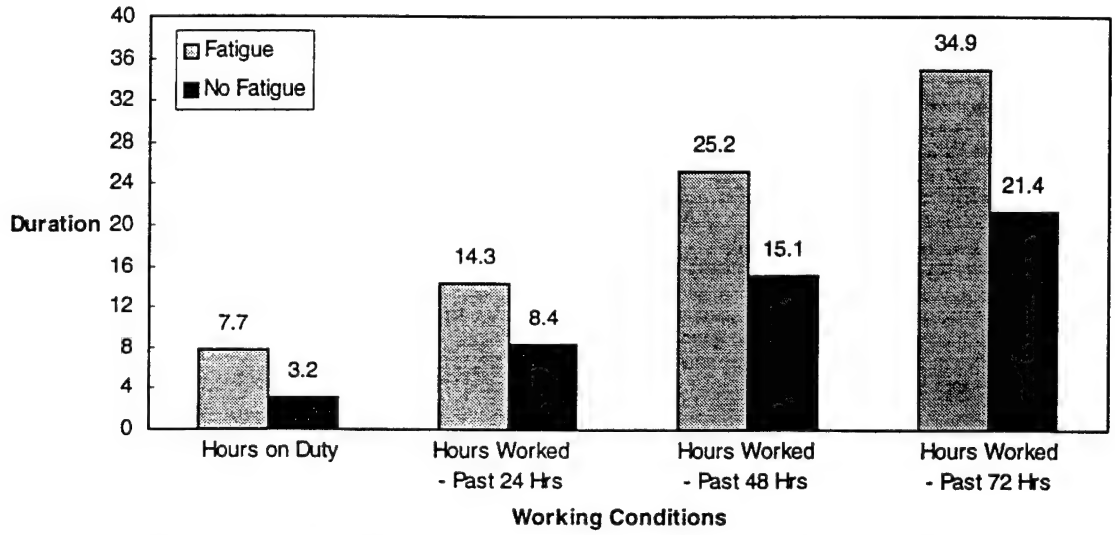

Figure 15. Comparison of working conditions found to significantly contribute to fatigue-related personnel injury casualties.

4. CONCLUSIONS AND RECOMMENDATIONS

This section presents our conclusions regarding the findings of the present study and our recommendations for future actions. The section is organized around three issues:

- Investigation and reporting of fatigue contribution to marine casualties;
- Future studies of human factors contributions to marine casualties; and
- General issues in the investigation and reporting of human factors contributions to marine casualties.

4.1 Investigation and Reporting of Fatigue Contributions to Marine Casualties

This project was successful in developing and implementing procedures for investigating and reporting information directly relevant to the contribution of fatigue in marine casualties. In conducting our analyses, we found that we could not rely directly upon mariner and IO judgments of fatigue involvement as a means of identifying casualties with a fatigue contribution. Of the 23 cases identified by either an IO or mariner as involving fatigue, there was agreement on only 11 (48 percent). Investigating Officer and mariner judgment did, however, support the development of the Fatigue Index procedure which provided an objective technique for identifying casualties that were likely to have a fatigue contribution.

Analysis of the potential objective indicators of fatigue resulted in the identification of three factors — the number of fatigue symptoms reported by the mariner, the number of hours worked in the 24 hours prior to the casualty, and the number of hours slept in the 24 hours prior to the casualty — that could be combined to calculate a Fatigue Index score for those cases with these data available. Applying an empirically determined cut-off point to the computed Fatigue Index scores resulted in the identification of casualties that were likely to have a fatigue contribution. This Fatigue Index procedure resulted in estimates that fatigue was a contributor to 16 percent of critical vessel casualties and 33 percent of the personnel injury casualties. Further development of this Fatigue Index procedure, through its application on a larger sample of casualties, should lead to an efficient and effective method of identifying casualties during investigation, that have a likely fatigue contribution.

Of the 144 critical vessel and 144 personnel injury cases, 40 critical vessel cases and 53 personnel injury cases had sufficient data to calculate a Fatigue Index score. Although this small sample limits the application of any findings stemming from our analysis, it was adequate to make some general assessments regarding the value of the collected fatigue data. The analysis of the fatigue data demonstrated that this approach could identify significant trends in involved industry segments and working conditions. In the case of critical vessel casualties, a number of significant contributors to fatigue were identified: (1) number of consecutive days worked prior to the casualty; (2) number of days worked in the 30 days prior to the casualty; (3) hours on duty prior to the casualty; (4) hours worked in the past 24, 48, and 72 hours prior to the casualty; (5) any change from the normal working schedule

prior to the casualty; and (6) the absence of company or union policies governing work hours. A subset of these factors were also identified as significant contributors to fatigue in the personnel injury casualties. These findings demonstrate that a larger application of the present methods would likely identify those working conditions that contributed to fatigue in investigated casualties.

Recommendation: Apply the fatigue investigation and reporting procedures to all critical vessel and personnel casualties investigated by the Coast Guard for a one-year period.

We recommend that revised versions of the procedures used in this study be applied in the investigation and reporting of all critical vessel and personnel casualties under the Coast Guard's purview for a period of one year. Implementation of these procedures should involve revised training sessions, investigation and reporting instructions, a periodic newsletter, the review of all reports by a team of human factors specialists, and a quality assurance process that provides feedback to IOs regarding additional actions required on specific cases. The resulting data should prove adequate to identify industry segments that require attention to reduce the rates of fatigue-related casualties. The data should also support the identification of working conditions that are contributing to fatigue-related casualties. In addition, these data should provide an adequate basis for developing a streamlined screening procedure for identifying casualties that are likely to have a fatigue contribution in future casualty investigations.

4.2 Future Studies of Human Factors Contributions to Marine Casualties

This project has demonstrated the feasibility of using a small-scale pilot study approach to develop investigation, reporting, and analytical procedures that have the two-fold value of (1) helping to understand the nature of the problem and (2) developing specific procedures that can be applied in a broader study to refine and validate these initial findings.

Recommendation: Support the conduct of additional focused human factors investigation and reporting pilot studies.

The approach and methods developed in this study can be applied directly in the research of other human factors contributions to marine casualties. Specific topics for similar pilot studies should be identified using available casualty data. Potential topics of study include mariner workload, working environment hazards, equipment usability, aids to navigation, communications and coordination, and training. With the support of Headquarters, the USCG Research and Development Center and Battelle will commence a second pilot study of this type in August 1996. Headquarter's support will be required in reviewing preliminary plans, coordinating MSO participation, and conducting various analyses of historical MINMOD data.

4.3 General Issues in the Investigation and Reporting of Human Factors Contributions to Marine Casualties

In this study, we excluded 188 cases from the initial sample of 467 vessel and personnel injury casualties to provide a focused analysis of critical casualties. Of the 467 cases, 70 were considered out of scope because of their specific nature (groundings in common areas and bridge allisions causing no damage, passenger injuries, and deaths by natural causes) and an additional 118 were classified as "minor vessel casualties." A total of 279 cases (60 percent of the original cases) were classified as a personnel injury, a critical vessel casualty, or both and included in the full series of analyses. We think that this approach resulted in more meaningful results that focused on relatively important casualties.

This study provided participating IOs with limited training that gave them an overview of basic human factors concepts, guidance regarding decisions that were required during the investigation process, a basic structure for conducting interviews, and detailed instructions regarding the completion of investigation reports. Investigating Officers who received this training were generally positive about its value and many IOs expressed the need for more training of this type.

In developing the investigation and reporting procedures used in this study, we were well aware of the difficulties currently encountered by IOs in their attempts to apply the MINMOD procedures to the investigation and reporting of human factors causes, as documented by Byers, Hill, and Rothblum.[2] We had some success in the present project in minimizing the ambiguity of the fatigue investigation and reporting process by providing a relatively clear definition of human factors contributions to casualties and by limiting much of the information collected to well-defined data. Human factors investigations often require a broader scope than this study. However, the same principles of providing unambiguous definitions of required decisions and collection of well-defined data can still be applied.

The project team's initial drafts of investigation and reporting procedures required revision to better match the IOs' job, aspects of the maritime industry, and characteristics of mariners. Additional vessel types were added to include the types of vessels commonly involved in casualties. Also, some of the questions had to be revised to better match aspects of mariner performance that the mariners could understand and be willing to discuss. These revisions were the direct result of Investigating Officers' suggestions. This direct involvement of the IOs in the design of the investigation and reporting procedures substantially improved the quality of the final product.

Much of the increase in the IOs' workload associated with the present project was the result of the requirement that IOs contact and interview all mariners who directly contributed to a casualty. We found over the course of this project that, in a number of MSOs, mariners who directly contribute to a casualty are not typically contacted. Current investigation and reporting procedures do not require this level of mariner contact. However, the investigation of human factors contributions to casualties will require contacting the mariner in almost every case, whether the investigation is addressing human factors issues broadly or in a more focused way, such as this study. If human factors are to be systematically

investigated by the Coast Guard, it must be recognized that involved mariners must be contacted and interviewed.

Analyses indicated an 84 percent overall agreement rate between researchers and IOs on whether human factors directly contributed to the reported casualty. We also found that IOs had a 25 percent miss rate on identifying human factors casualties, revealing a tendency for IOs to classify casualties as not related to human factors. Thus, IOs were only moderately reliable in their identification of direct human factors contributions to casualties. The present study relied upon human factors researchers to act as the final arbiters in determining the direct contribution of human error in the casualties studied. Overall validity and reliability of the findings in this study would have been reduced without this function.

During our direct contact with the four participating MSOs, we were able to observe a broad range of standard operating procedures and investigation strategies. For example, only one of the four MSOs typically dispatches IOs to the scene of the casualty or to the vessel as soon as possible following a casualty. We think that some of these procedures and strategies are more successful than others in obtaining current, valid, and reliable casualty information. Improvements in the reliability and validity of human factors casualty data must be coupled with standardization and improvements in the MSOs' procedures and investigation strategies. Many of these improvements are the "best practices" currently in place at some MSOs, which could be identified and adopted as standards across the Coast Guard.

The Investigating Officers participating in this study were uncertain as to the priority of investigating and reporting human factors contributions to casualties within the Coast Guard. All of the individual initiatives discussed above presume a centralized effort within the Coast Guard to systematically address the human causes of marine casualties.

Recommendation: Apply the general principles from the present project in upgrading current human factors investigation and reporting procedures.

The conclusions discussed above correspond to a number of recommendations that can be applied in upgrading current Coast Guard human factors investigation and reporting procedures.

- Limit human factors investigation, reporting, and analyses of marine casualties to cases in which the outcome of the casualty represents a significant threat to the environment or mariner safety.
- Provide IOs with training that addresses basic human factors knowledge, as well as investigation techniques and procedures to ensure the consistency of investigations and reliability of reported data.
- Develop casualty investigation and reporting procedures that provide unambiguous specifications of data to be collected and decisions required by the IO.
- Directly involve Investigating Officers in the design of any new investigation or reporting procedures.
- Recognize that the investigation of human factors requires analysis of the mariner's role in a casualty and that direct contact with involved individuals is essential.

- Establish an investigation report quality assurance process that includes expert review of incoming casualty reports for accuracy and completeness of human factors data and provides regular feedback to individual Investigating Officers.
- Develop a set of "best practices" for investigation and foster their adoption in all MSOs.
- Establish the investigation and reporting of human factors contributions to marine casualties as a Coast Guard priority in all MSOs.

4.4 Summary

This research and development project was successful in developing procedures for investigating and reporting direct human factors and fatigue contributions to marine casualties, and implementing these procedures in four MSOs over a six-month period. This limited effort was adequate to determine that the procedures were usable and could be modified for broader application. The next step in the investigation of fatigue is to make a transition from research and development to operational implementation, to obtain the casualty data necessary for definitive answers to the issues addressed in this study. The approach and methods developed in this study can also be applied in other research and development pilot studies addressing other human factors contributions to marine casualties. Finally, much of what we have learned in this study has broader implications for upgrading the investigation and reporting of human factors contributions to marine casualties within the Coast Guard. Continued effort in all three of these areas holds promise for reducing future rates of human-related marine casualties.

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[3]U.S. Coast Guard. *Prevention Through People Quality Action Team Report.* Washington, DC: U.S. Coast Guard Office of Marine Safety, Security, and Environmental Protection and Office of Navigation, Safety, and Waterways Services, July 15, 1995.

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[7]Nottrodt, J. (1994). *An Integrated Process for Occurrence Investigation,* (draft document). Ottawa-Hull, Canada: Transportation Safety Board.

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APPENDIX A

Instructions and Forms for Casualty Investigation and Reporting

INSTRUCTIONS FOR COMPLETION OF FORM A, CASUALTY BACKGROUND AND HUMAN FACTORS SCREENING AND FORM B, FATIGUE INFORMATION
REVISION #3

INTRODUCTION

These two forms (A & B) are to be used as data collection tools for a USCG R&D Fatigue Investigation and Reporting Research Project conducted by Battelle. This project is a pilot study designed to investigate the feasibility and usefulness of gathering additional human factors information pertaining to fatigue in maritime casualties. The information gathered as part of this study will remain confidential and will not be used to make modifications to the existing USCG Regulations.

As an Investigating Officer, your role in this project is crucial and we would greatly appreciate your cooperation. Your role in this project will be to screen casualties for their human factors involvement and to collect additional fatigue-related information for those casualties which qualify as human factors related. To facilitate your task in this project, we have developed a set of forms that will guide you in the gathering of fatigue-related information.

Given your expertise as investigating officers, we would appreciate greatly your opinions and comments regarding these forms, the types of data that should or could be collected, and the type of information that you would consider essential. In addition, your understanding of the procedures, forms, and type of data to be collected is critical to this project. If at anytime during the data collection process you have questions, comments, or suggestions, please contact us; we would like to know about them. We can be reached at the following numbers:

Dr. Marvin C. McCallum
tel: 206-528-3242 fax: 206-528-3552
email: McCallum@battelle.org
Ms. Mireille Raby
tel: 206-528-3234 fax: 206-528-3552
email: Raby@battelle.org

We thank you very much for your collaboration.

COMPLETION OF THESE FORMS

These forms should be filled out as completely and accurately as possible. Please type or print clearly. Fill in all blanks that apply to this specific casualty. **If a question is not applicable, the abbreviation 'N/A' should be used. If an answer is unknown and/or cannot be obtained, please write 'UNKNOWN'. Finally, if the answer to a question is none, please indicate 'NONE.** For any of the questions, if you need to add additional information or explain an answer, please do so in the space provided or in the margins.

When Form A is completed, proceed to complete Form B for each one of the involved individuals and any other interested party to the casualty (e.g., witness, co-worker, safety officer).

When all Forms A & B are completed for a casualty, please forward them to Battelle, **along with a copy of Form 2692, the MCIR, and, if applicable, the MCDD, MCPC, MCNS and MCHF.** Dr. Marvin C. McCallum, Battelle, 4000 NE 41st, Seattle, WA, 98105-5428. Thank you!

FORM A INSTRUCTIONS

General

This form should be completed for all **Vessel** and **Personnel** casualties, including casualties occurring on **oil platforms**. **Do not do Pollution casualties.**

Vessel /Platforms Casualties:
- Complete a Form A for each vessel involved in the casualty.
- You may skip item 17.

Personnel Injuries (including on Platforms):
- You can use a single Form A for one or several injuries corresponding to the same incident. However, make sure you can maintain clarity of information.
- You may skip item 16

Form A Detailed Instructions

The following paragraphs offer additional information and guidelines for some of the items to be completed. If you have additional questions, please contact us.

Section 1. Investigating Officer's Information

Item 3. Date at which you were given this casualty case to investigate (MCIR date).
Item 4. Enter the date at which all forms (A & Bs) were completed.
Item 5. Enter the time you spent contacting the individual to obtain or verify information to be included on Form A only. (24:00)
Item 6. Enter the time to transfer the information on the form. (24:00)

Section 2. Form 2692 Information

Item 7. Insert the same case number as the one used for your USCG investigation.
Item 11. Check the appropriate box to describe the vessel type. If none of these categories is right, please select 'other' and specify.
Item 12. Describe the main activity at the time of the casualty (e.g., fishing, underway, *moored, anchored, unloading,* etc).
Item 15. Mostly for vessel casualties. Please enter the total monetary value. If this information is known for a personnel injury, include it.
Item 16. For vessel casualties only. Check only one. Check the one that you would use in MCIR.
Item 17. For personnel casualties only. Check only one. Check the one that you would use in MCIR or that best describes this casualty.
Item 18. Indicate where the vessel was at the time of the casualty.
In port: Vessel is moored or anchored.
Restricted water: Areas in or adjacent to narrow channels and traffic separation zones, and areas of monitored traffic. Includes maneuvering around a dock.
At sea: Areas outside of port and restricted waters, including deep sea fishing grounds and large lakes.
Item 19. Indicate whether the environmental conditions, such as current and wave height had an influence on the mariner's work by creating low, medium, or high demands.

Section 3. Human Factors Screening

In completing Section 3, we ask that you identify every individual who, through their decision, action, or inaction contributed directly to the outcome or severity of the casualty. In considering this issue, you should include those individuals who played an active role in the sequence of events that led up to the casualty.

In that regard, here is a list of some individuals to consider:

- Individual who committed the last action/decision prior to the casualty.
- Individual who was injured.
- Individual who is mentioned in the 'Description of Casualty' in Form 2692.
- Individual who was in charge of vessel activities.
- Individual who was supervising the injured person.

In this section, you need to enter the name and position of each involved individual as well as their decision, action, or inaction.

Decisions, actions, or inactions should be described in a few words. You are looking for decisions or actions that, given the circumstances, were ineffective or inappropriate. These decisions or actions might not have been the most immediate to the casualty, but might have contributed directly to the sequence of events. You are looking also for decisions or actions that were not taken, but which would be expected to be taken by most mariners. Examples of decisions, actions, or inactions are listed in Form B, item 25.

By identifying decisions, actions, or inactions, you are not necessarily identifying the root cause of the casualty and attributing blame. You are simply pointing to the presence of a human factors contribution.

Finally, if one or more such individuals are identified, **Form B should then be completed for each one of these individuals**. If no one is identified, do not complete Form B.

FORM B INSTRUCTIONS

General

This form should be completed for **each one of the involved individual** identified in Section 3, Form A (Human Factors Screening).

In addition, please complete this form for any person (e.g., witness, safety officer) who has additional information about an involved individual that is critical or relevant to this casualty. In these instances, you need to enter information that pertains to the involved individual. In some instances, you might wish to enter the witness' activities at the time of

casualty; however, make sure that you indicate that it is the witness' activities and not the involved individual's activities.

Form B Detailed Instructions

Item 1. Enter the same case number as used on Form A and your USCG investigation.
Item 2. Enter the name of the individual who is involved in the casualty.
Item 4. Indicate the dates at which you contacted this person to obtain the information. Try to spread the calls across time. If the person cannot be contacted, write the date on Drop.
Item 5. In general, this person will be the involved individual. However, if it is a different person (e.g., master, safety officer), please indicate his or her name and position.

Section 1. Casualty Day

Item 8. Indicate the activities of the involved individual at the time of casualty. If you are interviewing a witness, you may wish to indicate the witness' activities. If so, **make sure that you specify that it is the witness' and not the individual's activities.**
Item 9. Write the location where the involved individual was at the time of casualty.
Item 10. Time on duty includes breaks that are less than 30 minutes long. If mariner takes a break longer than 30 minutes, it indicates the beginning of second work period.
Item 11. Indicate the last time that the individual had a break (not a nap) **while working,** within the last 24 hours prior to the casualty. A break is anything between 10 to 30 minutes.
Item 12. Snacks do not count.
Item 13. Check if the involved individual had a different work/rest schedule on the day of casualty comparatively to his/her regular schedule (e.g., less sleep, different activity).
Item 14. As much as possible, read each one of these items to the involved individual.These factors should be recorded in regards to the individual's activities at time of casualty. These factors should be sufficiently noticeable (e.g., disruptive, high, cold/hot) to affect the individual's task, concentration, or well-being.
Item 15. As much as possible, read each one of these items to the involved individual.

Section 2. Working Schedule

Item 17. Each box represents a day. For example, box 1 is the first day prior to casualty, box 23 is the 23rd day prior to the casualty. Shade each box for which the individual had a 24-hour period without duty obligations.
Item 18. **Please NOTE:** *Naps have been removed and are now part of the sleep 'block'. Sleep includes naps and times when the individual is lying down but is not asleep. We have also included recreation for all non-work activities.* Normal schedule: schedule most frequently used in the last 30 days. If it varies according to the vessel activities (e.g., in port vs at sea), please indicate it. **Do not forget to ask about their workload level, fatigue level, and sleep quality.**
Item 19 to 22. These 4 items are equivalent of asking the individual only 1 question: What was your working, recreational, and sleep schedule in the last 72 hours? First mark the time of the casualty with a vertical line drawn across the 4 items. Then, starting at the time of the casualty, indicate (by filling in the small half-hour boxes) the times at which the individual worked, recreate, and slept (includes naps) over the 3 days preceding the casualty. Indicate 'FORGOT when individual cannot remember at all. **Do not forget workload level, fatigue level, and sleep quality**.
Item 23. In addition to existing regulations, does the company or union have policies regarding work hour limitations? Indicate the maximum number of hours allowed to work in a given period.
Item 24. **Ask this question directly to the individual** and always ask 'why'.

Section 3. For IO only

Item 25. Assess the action or decision taken by the involved individual that contributed to the outcome or severity of the casualty.
Item 28. Answer this question once you have completed the interview. If rating is low, indicate why you feel this way.
Item 29. Time spent asking the questions and calling the involved individual to obtain or verify the information to complete Form B only.
Item 30. Time spent transfering the information on Form B only.
Item 35. Enter any additional comments made by the person contacted regarding any factors that could prove useful in understanding the sequence of events and the rationale behind certain actions/decisions.

If you have any questions, do not hesitate to call.
Thank you!

Form A: Casualty Background and Human Factors Screening

Section 1. Investigating Officer's Information

1. Name of Investigating Officer		2. Marine Safety Office ☐ HMRMS ☐ SEAMS ☐ MORMS ☐ SFCMS	
3. Date case was received (dd/mmm/yy)	4. Date Form A and B were completed (dd/mmm/yy)	5. Time spent investigating Form A	6. Time spent completing Form A

Please complete all items in Section 2 by transferring the information from Form 2692, or obtaining the information directly from the reporting individuals if the information is missing. It is important to obtain complete information.

Section 2. Form 2692 Information

7. USCG Case Number	8. Vessel Name	9. Vessel Nationality	10. USCG COI issued ☐ Yes ☐ No
11. Vessel type ☐ tug/barge ☐ freighter ☐ passenger ☐ processor ☐ tanker ☐ platform ☐ fishing ☐ other_____			12. Vessel activity at time of casualty
13. Date of Casualty (dd/mmm/yy)		14. Time of Casualty	15. Estimated loss or damage $

16. Type of Vessel Casualty *(check all that apply)*

☐ Cargo Lost/Damaged	☐ Heavy Weather Damage	☐ Electrical Failure
☐ Collision	☐ Fire	☐ Structural Failure
☐ Allision	☐ Explosion	☐ Emergency Equipment Failure
☐ Grounding	☐ Ice Damage	☐ Lifesaving Equipment Failure
☐ Wake Damage	☐ Damage Navigation Aids	☐ Blowout
☐ Flooding	☐ Steering Failure	☐ Other_____
☐ Capsizing	☐ Machinery or Equipment Failure	
☐ Foundering or Sinking		

17. Type of Personnel Injury *(check all that apply)*

☐ Slip/Fall	☐ Electric shock	☐ Sprain/Strain
☐ Overboard	☐ Cut	☐ Diving
☐ Struck by Object	☐ Entangled	☐ Death
☐ Pinch/Crush	☐ Asphyxia	☐ Presumed dead
☐ Burn/Scald	☐ Amputation	☐ Unknown
		☐ Other_____

18. Voyage Phase	19. Environmental Demands (Wave height, river stage, current, etc.)
☐ In port ☐ Restricted waters ☐ At sea	☐ N/A ☐ Low ☐ Medium ☐ High

To continue investigating and reporting the potential fatigue contributions of this case, you must determined if one or more individuals were directly involved in the casualty. Please identify below all individuals directly linked to the casualty.

Section 3: Human Factors Screening

20. Were there any individuals whose decision(s), action(s), or inaction(s) were directly linked to the casualty? ☐ No ☐ Yes *(If yes, provide information below.)*

Name	Position	Decision(s)/ Action(s)/Inaction(s)
Name	Position	Decision(s)/ Action(s)/Inaction(s)
Name	Position	Decision(s)/ Action(s)/Inaction(s)

*If no individual committed an inappropriate action or decision, (please attach a copy of **Form 2692, the MCIR, and, if applicable, the MCDD, MCPC, MCNS and MCHF** to this form) and forward them to Battelle. If you have identified one or more contributing individuals, please complete Form B.*

Form B: Fatigue Information - Side 1

*Form B should be completed for **each** contributing individual identified in Section 3, Form A, (i.e., who were directly linked to the casualty) or any other interested party to the casualty (e.g., witness, safety officers).*

1. USCG Case Number	2. Name of Involved Individual _____ Age _____	3. Position
4. Date of Call or Contact Call #1_____ Call #3_____ Call #2_____ Drop _____	5. Name of Person Contacted	6. Position

Section 1: Casualty Day

7. Experience of involved individual

	year(s)	month(s)
a) in the industry	_____	_____
b) with this company	_____	_____
c) in present job or position	_____	_____
d) on present vessel	_____	_____

8. Individual's activity at time of casualty	9. Specific location on vessel
10. Number of hours on duty at time of casualty	11. Any break (awake) prior to casualty? ☐ No break ☐ Yes, when _____
12. Time and last meal (breakfast, lunch, dinner) taken prior to casualty	13. Was the schedule on day of casualty different from usual? ☐ No ☐ Yes a. What was the difference?_____ b. How long had you been on this schedule?_____

14. Did you experience any of these factors during the last 24 hours prior to the casualty? *(Check all that apply.)*

☐ Disruptive ship vibrations	☐ Stormy weather	☐ Boredom	☐ None
☐ Disruptive ship motion	☐ Cold temperature	☐ High stress	☐ Other_____
☐ High noise level	☐ Hot temperature	☐ Demanding task	

15. Did you experience any of the following while you were on duty prior to the casualty? *(Check all that apply.)*

☐ Forgetful	☐ Distracted
☐ Difficulty keeping eyes opened	☐ Less motivated
☐ Difficulty operating equipment	☐ None
☐ Sore muscles	☐ Other_____
☐ Desire to sit or lay down	

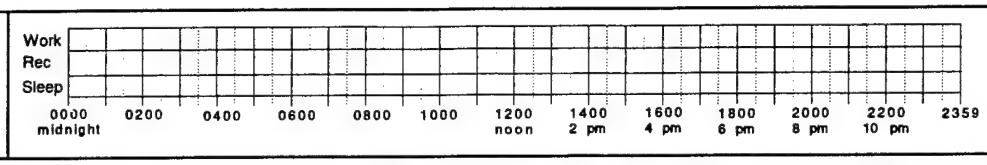
Section 2: Working Schedule

16. Number of days on tour at time of casualty (including shipyard)

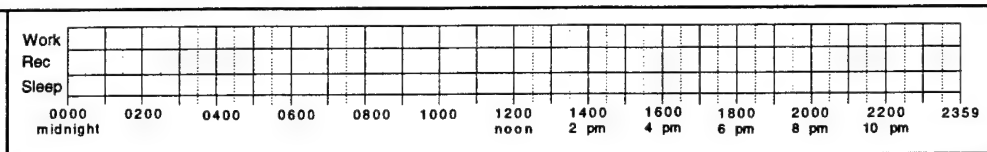
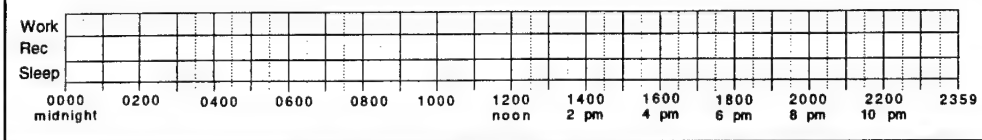
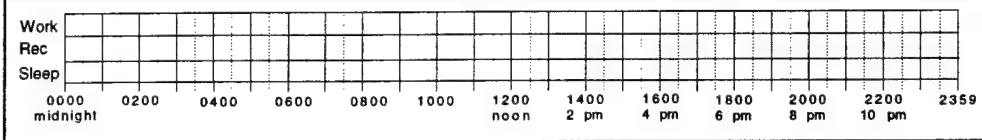
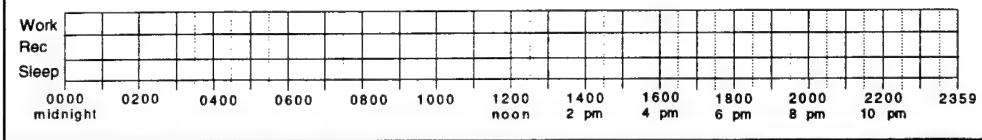
17. Please shade the days on which you had 24 hours off in the previous 30 days

30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Day of Casualty

Form B: Fatigue Information - Side 2

18. Normal Schedule		very low 1 2 3 4 5 very high Workload level ☐☐☐☐☐ Fatigue level ☐☐☐☐☐ Sleep quality ☐☐☐☐☐

*From the time of casualty, trace back the **work, recreation, and sleep** periods for the last 72 hours (3 days) prior to the casualty. Sleep also includes naps. Please mark time of casualty with vertical line.*

19. Day of Casualty		very low 1 2 3 4 5 very high Workload level ☐☐☐☐☐ Fatigue level ☐☐☐☐☐ Sleep quality ☐☐☐☐☐
20. Day 1 Prior to Casualty		very low 1 2 3 4 5 very high Workload level ☐☐☐☐☐ Fatigue level ☐☐☐☐☐ Sleep quality ☐☐☐☐☐
21. Day 2 Prior to Casualty		very low 1 2 3 4 5 very high Workload level ☐☐☐☐☐ Fatigue level ☐☐☐☐☐ Sleep quality ☐☐☐☐☐
22. Day 3 Prior to Casualty		very low 1 2 3 4 5 very high Workload level ☐☐☐☐☐ Fatigue level ☐☐☐☐☐ Sleep quality ☐☐☐☐☐

23. Are there any company or union policies regarding work hour limits? ☐ No ☐ Yes Maximum hours:_____	24. In the involved individual's opinion, was fatigue a contributing factor to this casualty? ☐ No ☐ Yes Why:_____

Section 3: For IO Only

25. What was the decision/action that was considered improper given the existing circumstances?

☐ Failure to secure equipment	☐ Failure to recognize code/symbol	☐ Erroneous judgment of situation
☐ Failure to notice something important	☐ Failure to decide on an action	☐ Erroneous calculations
☐ Failure to take action at proper time	☐ Forgetting to accomplish task	☐ Improper procedures
	☐ Prone to take risks	☐ Slow reaction to circumstance
		☐ Other _____

26. a) Was alcohol/drug testing done? ☐ Yes ☐ No b)Was the result: ☐ Positive ☐ Negative ☐ No result	27. In the IO's opinion, was fatigue a contributing factor to this casualty? ☐ No ☐ Yes, Why_____

28. On a scale of 1 to 5, do you feel that the mariner gave you true and accurate information? ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 1 = not at all true & accurate; 5 = extremely true & accurate	29. Time spent investigating Form B	30. Time spent completing Form B

Additional Comments

*Please conduct the necessary investigations to complete Form B for all contributing individuals. Upon completion of all Form B, attach a copy of **Form 2692, MCIR, MCDD, MCPC, MCNS and MCHF**, if applicable, to this form and forward them to Battelle*

Rev. 3

APPENDIX B

Investigating Officer Training Materials

Human Factors in Casualty Investigations

Investigation and Reporting Procedures

Marine Safety Offices
June 1995

Project Team

U.S. Coast Guard R & D

- Contract Monitor — Anita M. Rothblum, Human Factors Research Scientist

Battelle

- Program Manager — Thomas F. Sanquist, Senior Research Scientist
- Project Manager — Marvin McCallum, Senior Research Scientist
- Principal Investigator — Mireille Raby, Research Scientist

Project Goals

1. Conduct a pilot study to assess feasibility of focused approach
2. Obtain meaningful fatigue data to assist USCG identifying trends & increase safety
3. Enhance investigation of human factors in maritime casualties
4. Support Prevention Through People

Project Plan

1. Survey other casualty databases
2. Develop investigation procedures & forms
3. Implement procedures at selected MSOs
4. Assess and modify procedures
5. Continue investigation and reporting
6. Obtain final MSO feedback
7. Analyze data and report findings

Today's Training Schedule

Morning

- Project Goals & Training Objectives
- Human Factors & Human Error
- Fatigue Concepts
- Introduction to Investigating & Reporting Procedures

Afternoon

- Practical Exercises
  - Casualty Background and Human Factors Screening
  - Detailed Fatigue Investigation and Reporting
- Wrap-up

Training Objectives

1. Develop general understanding of :
   - project goals
   - human factors concepts
   - human errors in casualties
   - causes of fatigue
   - effects of fatigue
2. Become familiar with fatigue investigation & reporting procedures

What is Human Factors?

Multi-disciplinary approach to the study of human abilities and limitations and how characteristics of *machines* and of the *environment* (physical, organizational) interact to affect *human* performance.

Human Factors Perspective to Casualty Investigation

- Human-centered approach
- Which human capabilities & limitations?
- How do humans operate/maintain equipment, machine, or system?
- Under which operating conditions do humans act?
- What are the environmental conditions in which humans operate?

- Insert Reason's model here

Human Actions / Decisions

- In hindsight a human action/decision is labeled an error.
- Errors are unplanned, unintentional, and represent inappropriate actions in a given set of circumstances.
- Consequences of errors are the important factor to study.
- Only errors which have the greatest potential for reducing safety & system effectiveness should be investigated.

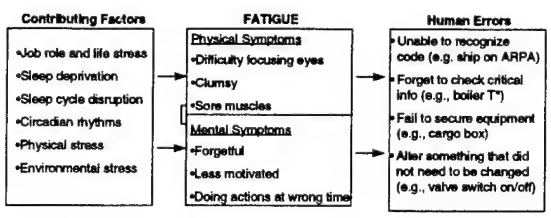
Why Fatigue?

- Transportation industry-wide focus
- Link to other USCG research projects
- MINMOD does not capture complete fatigue information
- First sample topic —→possibly other topics in future

What is Fatigue?

- Generalized response to stress over an extended period of time
- Caused by several contributing factors
- Has physical and mental symptoms
- Acute or long-term impairment
- Impairment contributes to human errors

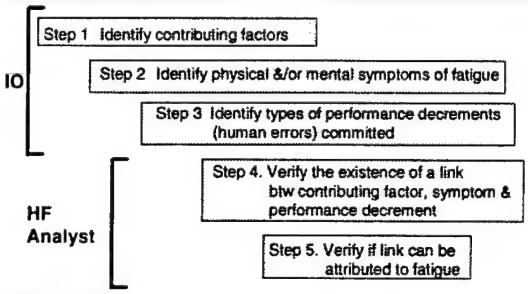
Fatigue Concept



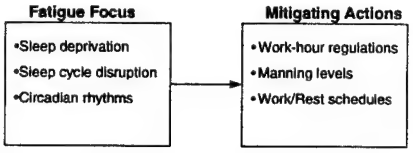
Types of Human Errors Caused by Fatigue

1. Cognitive response shift	>> difficulty in performing mental arithmetic >> difficulty in recognizing codes or symbols
2. Memory problem	>> difficulty in retaining information in memory >> difficulty assimilating new information
3. Time on task decrement	>> slow response to unexpected events
4. Optimum response	>> reduced fine motor coordination shift
5. Lapse	>> failure to react >> very slow to react to normal situation
6. False response	>> increased reporting & response to items that do not require a response

Steps to the Investigation of Fatigue



Where Should the Focus Be?...



Our Approach to Collecting Fatigue Information

1. Collect information that:
   - reflects existing conditions in industry
   - can be analyzed by USCG
   - can show meaningful trends in safety
2. For which casualties?
   - vessel casualties & personnel injuries
   - human factor involvement (action/decision)

Investigation Steps

FORM A

- Casualty background information from Form 2692
- Human factors screening

FORM B

- Fatigue data collection

Form A : Casualty Background and Human Factors Screening

Section 1. Investigating Officer's Information

1. Name of Investigating Officer
2. Marine Safety Office
3. Date at which you received the case
4. Date(s) at which the following information was obtained

Form A, continued

Section 2. Form 2692 information

5. Case Number
6. Vessel Nationality
7. USCG Inspected Vessel
8. Vessel Type
9. Vessel activity at time of casualty
10. Date of casualty
11. Time of casualty
12. Estimated loss or damage
13. Type of casualty

Form A, continued

Section 2. Form 2692 information, cont.

14. Type of Vessel Casualty
15. Type of Personnel Injury
16. Voyage Phase
17. Wave height, river stage, etc.

Form A, continued

Section 3. Human Factors Screening

Individuals to consider

- Individual who committed the action/decision linked to the casualty
- Individual who was injured
- Individual mentioned in the "Description of Casualty" in Form 2692
- Individual in charge of vessel activities
- Individual supervising the injured person
- Witnesses or co-workers

Form A, continued

Section 3. Human Factors Screening, cont.

Decisions, actions, or inactions that contributed directly to the outcome or severity of the casualty

- Decisions or actions that were inappropriate under the circumstances
- Inaction, when prudent seamanship would have led to an action that would have avoided or reduced the severity of the casualty

Decisions, actions, or inactions are not necessarily the root cause of the casualty

Form A, continued

Section 3. Human Factors Screening, cont.

Examples of decisions, actions, and inactions that contribute directly to a casualty:

- Failure to secure equipment
- Failure to notice something important
- Failure to take action at proper time
- Slow reaction to circumstance
- Failure to recognize code or symbol

Form A, continued

Section 3. Human Factors Screening, cont.

More examples of decisions, actions, and inactions that contribute directly to a casualty:

- Failure to decide on an action
- Forgetting to accomplish task
- Prone to take risks
- Erroneous judgment of situation
- Erroneous calculations

Form A, continued

Section 3. Human Factors Screening, cont.

Item 18 -- for each individual directly linked to the casualty provide:

- Name
- Position
- Decision(s), Action(s), and/or Inaction(s)

Form B : Fatigue Information

- Identifying Information
- Section 1. Casualty Day
- Section 2. Working Schedule

Form B, continued

Section 1: Casualty Day

7. Contributing Individual's activity at time of casualty
8. Specific location of vessel
9. Number of hours on duty at the time of casualty
10. Last break (awake) prior to casualty
11. Working schedule and activities in the 24 hours preceding the casualty
12. Was the schedule different from the usual?
13. Last meal taken prior to casualty

Form B, continued

Section 1: Casualty Data, continued

14. Exercise level
15. Illness or drug/alcohol consumption in the 24 hours preceding the casualty
16. Physical symptoms experienced prior to the casualty
17. Mental symptoms experienced prior to the casualty
18. Other factors experienced prior to the casualty
19. Subjective ratings of fatigue
20. Type of decision, action, or inaction contributing to the casualty

Form B, continued

Section 2: Working Schedule

21. Number of days on tour at time of casualty
22. Number of days since last day without duty obligations
23. Number of time zones crossed in last 7 days prior to casualty
24. Number of days since last time vessel was in port
25. Time in port
26. Days until next scheduled port call

Form B, continued

Section 2: Working Schedule, continued

27. Normal schedule time line
    - Work, Sleep, and Nap times

28–31: 72-hour schedule time lines
- Work, Sleep, and Nap times
- Quality of sleep
- Workload

Form B, continued

Section 2: Working Schedule, continued

32. Company policies regarding work hour limits
33. Opinion concerning contribution of fatigue
34. Confidence that information is true and accurate

Additional comments

Brief Review of Form A

- Definitions of terms
- How to determine information requirements
- How to identify which individuals to contact
- Form A instructions

Practical Exercise: Form A

Collision between bulk carrier Nand Anant and fishing vessel Carmanah # 1

- April 29, 1995, 0650
- Daylight, clear weather, good visibility
- 30 miles off Amphitrite Pt. (Barkley Sound), Vancouver Island., British Columbia
- Nand Anant holed amidships by Carmanah No. 1
- Both vessels proceeded under own power
- No personnel injuries

Sketch of the Area

insert drawing here.

Form 2692 Information

5. Case Number
6. Vessel Nationality
7. USCG Inspected Vessel
8. Vessel Type
10. Date of casualty
11. Time of casualty
12. Estimated loss or damage
13. Type of casualty
14. Type of vessel casualty
17. Wave height, river stage, etc.

Information Determined by IO

4. Dates when information obtained
9. Vessel activity at time of casualty
15. Type of personnel injury
16. Voyage phase
18. Human Factors Screening items

Potential Persons of Interest

- Individual who committed the last action/decision prior to the casualty
- Individual who was injured
- Individual mentioned in the "Description of Casualty" in Form 2692
- Individual in charge of vessel activities
- Individual supervising the injured person
- Witnesses or co-workers

Interview Topics

1. Verify facts
2. Ask for more detailed account of events
3. Introduce research topic
4. Identify individuals of interest
5. Review each individual's decisions, actions, and inactions

Interview with Captain of Carmanah #1

- One volunteer act as investigator
- Instructor act as respondent

Interview Notes and Conclusions

- Status of vessels (give-way & stand-on)
- Captain's decisions and actions
- Deck-hand's decisions and actions
- Cook's decisions and actions

Outcomes from Other Interviews

- Deck-hand interview
- Cook interview
- Nand Anant OOW

Completed Form A

- Carmanah #1
- Nand Anant

To Remember for Form A

- Verify and include Form 2692 information in Form A
- Contact the reporting individual and/or safety officer
- Be liberal at human factors screening
- Consider witnesses or key individuals who would know about circumstances

Brief Review of Form B

- Purpose is to gather fatigue information:
  - » for each contributing individuals
  - » from witness, co-workers who have important information about the events
- Two main sections:
  - » casualty day activities & fatigue factors
  - » working schedule & 72-hour history
- Definition of terms

Known Information about Accident Sequence

0400 - Bulk Carrier enroute Japan to Vancouver
- Fishing vessel leaves Ucluelet

0600 FV deck-hand sights Bulk C. & makes 20° course change to starboard

0630 - FV deck-hand wakes up cook
- FV cook does not replace deck-hand
- Bulk C. OOW sights FV (1.8 miles)

0650 Collision - FV struck port side of Bulk C.

Fatigue Information Obtained from 2692

Fishing Vessel (Carmanah #1)
- » departed early morning hours - 0400
- » clear weather, calm seas
- » Deck-hand on duty until 0630
- » Cook was woken up at 0630
- » collision occurred at 0650

Bulk Carrier (Nand Anant)
- » graveyard shift
- » Chief-Officer is OOW; Quartermaster is lookout

Potential Persons of Interest

Main Actors
- » FV Deck-hand (was on watch)
- » FV Cook (was to take watch)
- » BC Chief Officer (OOW)

Witnesses, other personnel
- » FV Skipper (to confirm info)
- » BC Quarter Master (if add'l info is needed)
- » BC Master (if add'l info is needed)

Interview Topics (Form B, p.1)

- Determine who you will talk to (main actors)
- Review what happened
- Ask about individual's activities & location at time of casualty
- Find out about individual's schedule on that day (work, rest, non-work, meals)
- Determine how individual was feeling. Any fatigue symptoms? contributors? (checklist)

Interview Topics (Form B, p. 2)

- Build a sense of individual's schedule since onboard & specifically over last 72-hour
- Ask question about relevant policies & SOPs
- Ask if fatigue played a role in casualty
- At the end
  - » determine human action/decision (#21)
  - » make statement about truth of information

Guidelines for 72-hour History

- Mark time of casualty & 72 hour timeline
- Guide the interviewee:
  - » How long on duty? Last break?
  - » Working schedule on that day? Workload?
  - » Sleeping/nap schedule on that day? Quality?
  - » Day before casualty: activities on that day? when? sleeping schedule?
- Summarize info obtained. Ask person to go back one more day prior to casualty. Same questions.

Practical Exercise Form B

Conduct interview with deck-hand of Carmanah #1

- » One volunteer to act as Investigator
- » Instructor act as contributing individual
- » IO asks questions to fill in Form B
- » Other IOs fill in Form B
- » Debriefing

Interview Notes and Conclusions

- Comments about the interview process
  - » any difficulties doing it?
  - » got all the information?
  - » what could be done differently?
- Comments about the form design
  - » format? (number of pages, double-sided)
  - » individual items? (phrasing, missing, n/a)

Completed Form B

- Deck-hand on Carmanah #1
- Cook on Carmanah #1
- Skipper on Carmanah #1
- Chief Officer on Nand Anant

Information Gathered from Additional Interviews

- Help to fill in missing parts of puzzle
- Obtain detailed sequence of events
- Gather different perspective of the events (each individual's perspective)
- Confirm/Refute information already obtained
- Obtain possible recommendations for safety actions

To Remember for Form B

- 1 form for each individual directly contributing to outcome or severity of casualty.
- If interviewing other person than contributing individual, specify whose information it is.
- Do not leave blanks (e.g., not asked, unknown, none)
- 72-hour history: sleep & nap periods are most important
- Use info to make judgment about actions (21)

Your Role in the Next Month

1. Conduct fatigue investigation for vessel & personnel injuries (no pollution)
2. Contact Battelle with inputs regarding:
   - » aim/focus of study
   - » data collection forms (format, questions)
   - » investigation and reporting procedures

Schedule for Pilot Study

1. One month assessment:
   - » Maintain contact with IOs
   - » Research team visits all IOs at 4 MSOs
2. 5 to 6 months data collection
3. Final evaluation of procedures
4. Research team provides feedback

Reporting Package

- Each casualty reporting package should contain:
  - » Form 2692
  - » Form A
  - » Forms B (if applicable)
  - » MCIR, MCNS, MCHF
- Collect all casualty reporting packages and send once a week

How to Contact Us

- By phone/fax
  - » Marvin McCallum 206-528-3242
  - » Mireille Raby 206-528-3234
  - » fax 206-528-3552
- By mail

  Battelle
  4000 NE 41st Street
  Seattle, WA, 98105-5428

APPENDIX C

Project Newsletters

Marine Investigator

August, 1995 Vol. 1 No. 1

GREETINGS

Hello to all of you at the MSOs who are supporting the *Human Factors in Casualty Investigation* project from the project research staff. We've put together this newsletter to inform you about recent project activities. During the next six months, we'll send out a few more newsletter issues to keep everyone informed about our progress. In this issue, we review the project goals and schedule, provide some feedback on the reports you've sent in, highlight some changes to the reporting forms, and respond to some frequently asked questions.

PLOTTING THE COURSE

Periodic review of project goals helps ensure that we're staying on course for our final destination. We find it useful to remember that this is a pilot study. The project has been designed to assess strategies for improving the way in which human contributions to marine casualties are identified, investigated, and reported within the Coast Guard. For this first pilot effort, we've selected fatigue as the topic to focus on. In the future, we hope to address additional topics as we refine the strategies employed.

The *Human Factors in Casualty Investigation* pilot project has three primary goals.

1. Enable the Coast Guard to determine how fatigue contributes to marine casualties,
2. Identify unsafe operating practices that lead to fatigue within the marine industry.
3. Enhance the Coast Guard's investigation of human factors in marine casualties.

THE LOG BOOK

We're only about one-third of the way through the investigation and reporting portion of our journey. Following are some of the waypoints on our planned course.

June 15 - July 2: Initial MSO training.

July 24 - August 9: Telephone conference calls between MSOs and research staff to review investigation and reporting status.

September 5-22: Research staff visits to MSOs to review investigation and reporting status and provide additional training.

Early 1996: Research staff visits to MSOs at the conclusion of fatigue investigation and reporting to assess procedures and discuss lessons learned with investigators.

REPORT FROM THE BRIDGE

We thought it might be interesting to share some initial findings from reports completed and forwarded to us. As we write this newsletter, approximately 165 cases had been opened by the four participating MSOs since initial training and we have received forms for 30 cases.

The table below summarizes the number of case reports completed and sent to our offices, the human factors status of those cases, and the preliminary fatigue status of those cases. Of the 30 cases completed, 18 (60%) have been identified as having a direct link to human factors, 9 (30%) have not, and the human factors involvement is unknown for 3 (10%) of the cases. Unknown cases are those where the mariner is not available to provide sufficient information to reach a conclusion.

The preliminary fatigue results are based upon the investigator's judgment regarding the role of fatigue and our review of the case. Out of the 30 cases, 6 (20%) were judged to have a fatigue involvement, 18 (60%) had no fatigue involvement, and 6 (20%) had an unknown fatigue involvement. If only those cases where a fatigue determination can be made are considered, 6 out of 24 cases (25%) appear to have some fatigue involvement.

Summary of Completed Cases

MSO	Cases Sent	Human Factors			Prelim Fatigue		
		Yes	No	?	Yes	No	?
HMRMS	33	0	3	0	0	3	0
MORMS	7	4	3	0	1	5	1
SEAMS	14	9	3	2	4	6	4
SFCMS	6	5	0	1	1	4	1
TOTAL	30	18	9	3	6	18	6

MINOR COURSE CORRECTIONS

The investigation of fatigue in marine casualties has been equated with filling in forms, and forms, and forms... We recognize that we are imposing on you by asking you to fill in Forms A and B. Some of you have indicated several concerns with the forms: (1) the forms are time-consuming; (2) some of the questions are embarrassing to ask - or not appropriate; and (3) most questions require direct contact with the mariner.

We've taken your comments into consideration and are now offering you a *revised* Form A & B **(Rev. 2)**. These new forms should reduce the time involvement and hopefully make the process a little easier to accomplish. We have kept the look but changed some of the content. Here are some highlights:

Form A

- A couple of new items will track the time spent investigating and completing the forms.
- The *Vessel type* item has been modified so that you can check the appropriate vessel category.
- Some of the *Type of personnel casualty* categories have been modified.
- We have revised the *Wave height, river stage, etc.* item and are asking you to indicate the influence of environmental factors on the casualty.

Form B

- If mariners can't be reached, Form B can remain incomplete. However, there are some criteria to satisfy.
- There is no longer a need to collect information on exercises, illness, time zones, and "in port" activities.
- Collecting physical/mental fatigue symptoms is now easier. There are fewer items and only one question.
- The dreaded 72-hour work/rest schedule is still there... hopefully the new format will make it easier to complete.
- We have added a *For IO Only* section at the end of the form that includes all of the items that ask questions directly of the investigator.

We hope that this new form will make the process of investigating fatigue a little easier for you. Please use it as soon as possible. If you have any comments, please contact us.

Dear Researcher

Good communications are essential to a successful collaboration between fuzzy-headed researchers (us) and level-headed practitioners (you). We share common goals in this project, but we have different obstacles to overcome in as we contribute to the success of the project. We've been listening to your concerns. Here are some of your questions and our answers.

☎ Why not let the IO determine if a casualty is fatigue-related or not?

💻 Unfortunately, most of the information on Form B needs to be collected whether it is a fatigue-related casualty or not. It is also difficult to evaluate whether a casualty involves fatigue unless some questions regarding the sleep/work schedule are asked. In some cases, it might seem obvious that fatigue is not a factor. However, because this is a pilot study, we do not know the best way to screen for fatigue. Obtaining this information will help us determine what it should be.

☎ Which forms do I need to send? Can't I just send Form A and Form B?

💻 For each casualty investigated, we need to get a Form 2692. We also need the MCIR, as well as the MCPC, MCNS, and MCHF (if applicable). Without these additional forms, it is very difficult for us to review Forms A and B and get an accurate picture of what happened.

☎ What if I can't reach the involved individual?

💻 There are three options. (1) If people can't be reached because they no longer have an address or phone, write it down on the forms and drop the case. (2) If a mariner is at sea, try a couple of times when they come back, then drop the case; again write it down. (3) In general, try to reach individuals three times; if they can't be reached drop the case. Sorry folks...a busy signal doesn't count...

☎ What do I do when the person does not even remember his own name, much less his sleep/work schedule?

💻 Try to collect as much as you can. However, please provide comments in the margin to indicate that the information "has been forgotten," "is not reliable," etc... It might appear useless to collect it in the first place. However, since this is a pilot study, collecting this type of information will enable us to evaluate whether this approach is viable.

THANK YOU!

Everyone at our end has been truly impressed with the cooperative and professional approach to this project by the participating MSOs. We realize this project is creating extra work for you, and we greatly appreciate your efforts!!

Marvin McCallum, Mireille Raby, & Anita Rothblum

Marine Investigator

November, 1995 Vol. 1 No. 1

GREETINGS

Hello again to all of you who are supporting the *Human Factors in Casualty Investigation* project. This is our second edition of the newsletter, which is designed to inform participating MSOs about recent project activities and issues. This issue of the newsletter briefly addresses the project schedule, summarizes recent findings from a preliminary analysis of your reports, and provides answers to some frequently asked questions. We hope that you will enjoy reading this second issue of the *Marine Investigator*. If you have any questions or comments, please do not hesitate to call us.

PLOTTING THE COURSE

We are aware that the National Transportation Safety Board (NTSB) is conducting a study on fishing vessel casualties, and that they have provided forms for you to fill out. Some of the questions on the NTSB forms overlap information we are collecting and we understand that the need to participate in both studies will impose additional demands on each Investigating Officer. If participation in the NTSB study is having a detrimental effect on your ability to complete Forms A and B, please contact Anita Rothblum, USCG R&D Center, at (860)441-2847.

THE LOG BOOK

The overall project schedule has not changed substantially since the publication of the first newsletter. Our intention is to include all new cases in this study through December 31, 1995. Following the December 31 cut-off date, IOs will be allowed two more months to complete the human factors/fatigue investigation on any open cases. Following are some updated project milestones.

- **September 11-29:** Visits were made to MSOs by project staff to review investigation and reporting status and to provide additional training.
- **December 31:** Cut -off date for new cases. After this, no new cases will be opened for the project.
- **January and February:** Two months to wrap-up the human factors and fatigue investigations of casualties that were opened between July 1 and December 31.
- **February 28:** All fatigue project cases should be completed. All Forms A and applicable Forms B should be mailed to Battelle.
- **March:** Final visits to MSOs to assess procedures and discuss lessons learned with investigators.
- **April:** Final report submitted to USCG R&D Center.

REPORT FROM THE BRIDGE

As of October 31st, we had received 120 sets of completed forms. We thought it might be interesting to share some initial findings based on those reports.

The table below summarizes the number of case reports completed and sent to us, the human factors status of those cases, and the preliminary fatigue status of those cases.

Of the 120 cases completed, 53 (44%) have been identified as having a direct link to **human factors**, while 65 (54%) have not. Two cases (2%) do not have a final determination regarding human factors involvement.

The preliminary **fatigue results** are based upon the investigator's judgment regarding the role of fatigue and our preliminary review of the case. Out of the 120 cases, 10 (8 %) were judged to have a fatigue involvement. If we consider only those human factors cases where a fatigue determination can be made, 10 out of 34 cases (29%) appear to have some fatigue involvement. By the way, you have identified 2 cases in which the mariner **fell asleep at the wheel.**

SUMMARY OF MSO ACTIVITIES

MSO	Cases Sent	Human Factors Yes	No	?†	Prelim Fatigue Yes	No	NR*	?†
HMRMS	32	4	27	1	1	3	0	1
MORMS	20	14	6	0	4	5	5	0
SEAMS	39	20	19	0	4	9	7	0
SFCMS	29	15	13	1	1	7	4	4
TOTAL	**120**	**53**	**65**	**2**	**10**	**24**	**16**	**5**

* NR = cases for which the mariner was **not reached**.
†? = cases for which a final determination has not been made.

Although these analyses reflect the reports obtained prior to October 31st, we would like to mention that so far, in November, we have received an additional 12 casualty reports from Hampton Road, 3 from Morgan City, and 21 from San Francisco. Thank you!

MINOR COURSE CORRECTIONS

In August we held discussions with IOs from each MSO to identify continuing problems with the forms and procedures. Based on your input, we made an additional set of changes to the forms, which we introduced during our September visits. We just want to remind you to use the latest version, which is **(Rev. 3)**.

Dear Researcher

How do we keep fuzzy-headed researchers (us) from going off on a collision course? By having the level-headed practitioners (you) questioning our investigation procedures and reporting forms. Here are some of your best questions and our best answers.

☎ What do I write in the action/decision item of the human factors screening section?

☺ If possible, describe the action or decision and how it was improper given the circumstances. For example, if someone slipped and fell going down slippery steps wearing street shoes when they should have been wearing non-skid shoes, 'wearing improper footwear' would be more appropriate than 'walking down steps'.

☎ Why do I need to write the estimated loss/ damage?

☺ We will be using these data to compare the loss 'associated' with human factors versus non-human factors casualties. In addition, this information will help us to determine the relative importance of specific casualty types in our later analysis. If the dollar amount for the loss is available, please include it. If it is not available, please indicate 'n/a'.

☎ What if I can't complete the full 72-hour history?

☺ We know it is the most time-consuming item of Form B, but we would still appreciate it if you could provide us with as much information as the mariner can remember. If the mariner doesn't have an exact memory of his/her schedule, try to get an estimate of the number of work, sleep, and recreation hours and the general time in which these activities occurred. Then, briefly note that the schedules are estimates. If you can't fill in the boxes for day 2 and 3, express in words the reasons why or describe some of the elements that the mariner remembers. So far, we have received a 24-hour history in 53% of the HF cases, and a 72-hour history in 38% of the HF casualties.

☎ What is the difference between 'n/a' and 'low' in the environmental factors item?

☺ Use 'n/a' when the environmental factors are not an issue in this type of casualty, even if they were high. For example, if personnel injury occurs below deck while a ship is moored during a severe storm, the stormy conditions were probably not applicable (although they may be). Use 'low' when environmental factors could have played a factor in the casualty, but in this particular case were low. For example, when a grounding occurs under good visibility and weather conditions.

☎ How do I differentiate between a Human Factors related casualty and a casualty due to Environmental Factors?

☺ First, consider the direct links of human factors in all cases before you make the conclusion that it was due to environmental factors. Did the mariner take an action that was not appropriate for the operational and environmental conditions? Did the mariner make a decision that did not properly take the operational and environmental conditions into account? Did the mariner fail to take action that would normally be considered prudent under the operational and environmental conditions? If your answer to any of these three questions is 'Yes', then you should conclude that human factors contributed to the casualty. Second, remember that there can be more than one cause to a casualty. If other casualties have occurred at the same location in similar circumstances and the mariner's role was inconsequential, the case can be attributed to environmental factors. However, if both environmental and human factors can be directly linked to the casualty, then the case should be investigated as a human factors casualty.

These are just a small sample of the questions we have been asked. If you have a question about the project you would like answered, please feel free to contact us.

Marvin: (206)528-3242

Mireille: (206)528-3234

THANK YOU!

Everyone at our end has been truly impressed with the cooperative and professional approach to this project by the participating MSOs. We realize this project is creating extra work for you, and we greatly appreciate your efforts!!

Marvin McCallum, Mireille Raby, & Anita Rothblum

APPENDIX D

Procedures Assessment Survey and Results

MSO Assessment Questionnaire

For the past six to eight months, you have been asked to participate in a pilot project on the investigation and reporting of human factors and fatigue information.

This questionnaire is designed to provide you with an opportunity to present your comments and suggestions in regards to the value of this approach to the investigation of human factors and fatigue-related information.

To facilitate your task when completing this questionnaire, we have attached copies of a) the newsletter, b) the instructions, c) the form A, and d) the form B.

Your responses are valuable to provide future directions to this pilot project and, as such, your participation is greatly appreciated! Thank you!

> *Note:* Incorporated throughout the Questionnaire are the results of each question. The numbers represent the number of people who chose that particular item. (n) indicates the total number of people who answered the question or the total number of choices offered by the respondents.

1. Background Information

1.1 MSO: 5 MSO #1 5 MSO #2 7 MSO #3 8 MSO #4 (n=25)

1.2 Name of Investigating Officer: _____

1.3 Rank: _____

1.4 Position:

a.	Senior Investigating Officer (SIO) or Assistant SIO 3	
b.	Investigating Officer (IO) 17	
c.	Part-time Investigating Officer (IO) 1	(n=25)
d.	Reservist or Civilian 4	

1.5 When were you assigned to this investigation office?

a.	Less than a year 13	
b.	One to two years 2	
c.	Two to three years 6	(n=24)
d.	Three to four years 1	mean=1.8 years
e.	Four years or more 2	range=3 mos. to 8 ½ yrs

1.6 When did you initially get involved with this project?

a.	June 95 11	
b.	July 95 6	
c.	August 95 3	(n=23)
d.	September 95 2	
e.	October 95 1	

1.7 How many vessel and personnel injury casualties were assigned to you between July 1, 1995 and December 1, 1995?

a. None	2	
b. 1 to 10	3	
c. 11 to 20	2	(n=15)
d. 21 to 30	3	mean=25 casualties
e. 31 to 40	2	range=0 to 80 casualties
f. 41 to 50	1	
g. 51 and above	2	

2. Training and Support Materials

2.1 Did you receive the full-day training provided by project staff at your office prior to July?

(n=24) 64% Yes 36% No *If yes, how would you rate this training on:*

(n=16)	Poor 1	2	3	4	Excellent 5	Mean
a) Explaining why you were completing forms	0	0	4	7	5	4.1
b) Describing what information you needed to collect	0	0	2	10	4	4.1
c) Describing how to complete the forms	0	0	2	11	3	4.1
d) Preparing you for this new role in your job	0	0	4	11	1	3.8

If you completed this item, please go to item 2.5.

2.2 If you did not receive the training prior to July, did you receive the half-day training provided by project staff at your office during September?

(n=9) 55.6% Yes 44.4% No *If yes, how would you rate this training on:*

(n=5)	Poor 1	2	3	4	Excellent 5	Mean
a) Explaining why you were completing forms	0	0	1	2	2	4.2
b) Describing what information you needed to collect	0	0	1	1	3	4.4
c) Describing how to complete the forms	0	0	2	1	2	4.0
d) Preparing you for this new role in your job	0	0	2	1	2	4.0

If you completed this item, please go to item 2.5.

2.3 If you did not receive either the June or September training from project staff, did you receive any training from your co-workers or supervisors at your office?

3 Yes 0 No Provided by Supervisor: 2

Provided by Co-worker: 1

If yes, how would you rate this training on:

(n=4)	Poor 1	2	3	4	Excellent 5	Mean
a) Explaining why you were completing forms	0	1	0	2	1	3.8
b) Describing what information you needed to collect	0	1	0	2	1	3.8
c) Describing how to complete the forms	0	1	0	1	2	4.0
d) Preparing you for this new role in your job	0	1	1	1	1	3.5

If you completed this item, please go to item 2.5.

2.4 a) If you received neither training from project staff nor training from your co-workers or supervisors at your office, how did you acquire the information necessary to complete the project requirements?

No one answered this question.

b) How would you rate the information that you have acquired in preparing you for this new role in your job?

Poor 1	2	3	4	Excellent 5
0	0	0	0	0

2.5 Please provide any recommendations you have for improving the training for the current project. Possible items of discussion are: a) content of information presented; b) handouts format in regards to refresher training; c) providing a videotaped training session to replace missed training.

1. Improve training by focusing on purpose of project and increase the amount of human factors information presented. 2
2. Keep consistent in the criteria under which Form A and B should be completed 2
3. (a) Make handouts more specific, with more examples
   (b) Make instructions more user-friendly. 2
4. Provide training video showing an IO interviewing a mariner to obtain information contained in Form A and B. ..... 2 (n=15)
5. Share the techniques used by various MSOs across all MSOs. 2
6. (a) Assign one of the IO to act as a project coordinator at each MSO
   (b) Use fully trained IOs to train other IOs. 2

7 Other 3

2.6 Did you receive a copy of the instructions for completing the forms?

(n=25) 100% Yes 0% No *If yes, please complete the following:*

(n=23)	Never	Occas-sionally	About Half the Time	Usually	Always	Mean
a) How frequently did you use the instructions during your investigation?	5	9	3	4	2	2.5
b) How frequently did you use the instructions during the preparation of the reporting forms?	3	6	6	5	3	3.0

If you used the instructions, how would you rate these instructions on:

(n=20)	Poor 1	2	3	4	Excellent 5	Mean
a) Ease of use	0	6	6	6	2	3.2
b) Value in conducting the investigation of Form A and B	1	5	7	4	3	3.2
c) Value in completing Form A and Form B	0	3	10	5	2	3.3

2.7 Did you receive one or more copies of the newsletter, the ***Marine Investigator*** (attached)?

(n=25) 100% Yes 0% No *If yes, how would you rate the newsletter on:*

(n=25)	Poor 1	2	3	4	Excellent 5	Mean
a) Keeping you up-to-date with the project	0	1	9	9	6	3.8
b) Summarizing the latest procedures to use	0	2	8	10	5	3.7
c) Answering your concerns and questions	0	5	10	6	4	3.4

3. Investigation and Procedures Forms

3.1 What is your understanding of the basic purpose of this project?

1. To determine whether fatigue contributes to marine casualties 14
2. To determine whether human factors contributes to marine casualties..... 7
3. To obtain a viable set of human factors data and establish a better database. .. 4 (n=28)
4. To evaluate the existing investigation process..... 2
5. To broaden MCHF and make human factors more understandable..... 1

3.2 What is your understanding of the purpose of Form A (attached)?

1. To gather or screen for basic information..... 17
2. To determine whether human factors contributes to marine casualties..... 12 (n=35)
3. To identify all marine casualties to be included in the project..... 6

3.3 In completing your investigations for Form A, what information did you use to assess whether a casualty was HF-related or not?

1. Statements made by the involved individuals or witnesses to the casualty..... 11
2. Form A (section 2) or the content of CG 2692..... 7
3. Form A (section 3): whether or not the individual was directly involved in the casualty..... 7 (n=33)
4. Type of casualty involved..... 5
5. MSO's philosophy and guidelines in assessing whether or not human factors or fatigue contributes to marine casualties..... 2
6. Own expertise as an investigator; the form did not help..... 1

3.4 How would you rate the Format of Form A in regards to:

(n=24)	Poor 1	2	3	4	Excellent 5	Mean
a) Ease of use	1	0	6	14	3	3.8
b) Contribution to quality of investigation	4	4	8	7	1	2.9

3.5 Any suggestions for improvements to Form A:

1. No changes required..... 5
2. Delete request for information that can be found on CG 2692..... 7
3. Change the Form's layout..... 1 (n=15)
4. Delete the questions on time required to complete and investigate Form A..... 1
5. Add other human factors criteria that are not captured by either Form A and B and add these to Form B..... 1

3.6 What is your understanding of the purpose of Form B (attached)?

1. To determine whether fatigue contributes to marine casualties..... 11
2. To gather human factors and/or fatigue-related information..... 10 (n=32)
3. To determine whether human factors contributes to marine casualties..... 6
4. To gather specific information related to the project..... 5

3.7 Which criteria/information did you use to determine if a casualty was fatigue-related or not?

1.	Work history, hours on duty, workload level, type of activities.	9	
2.	Sleep history (24-hour and/or 72-hour).	8	
3.	The information gathered during the interview process	8	
4.	Form B (item #24): mariner admitting to be tired.	4	(n=40)
5.	IO's expertise and knowledge of the investigation process and of the maritime industry.	3	
6.	Type of casualty	2	
7.	Form A (section 2) or the CG 2692.	2	
8.	Form A (section 15): physical characteristics and fatigue symptoms.	2	
9.	IO's perception of the truthfulness of the information provided by the mariner.	1	
10.	Whether or not the mariner was directly linked to the casualty	1	

3.8 How would you rate the Format of Form B in regards to:

(n=23)	Poor 1	2	3	4	Excellent 5	Mean
a) Ease of use	2	8	5	7	1	2.9
b) Contribution to quality of investigation	0	7	6	9	1	3.2

3.9 What percentage of time did the mariner:

a) refuse to answer the Form B questions:

0 to 25 percent of time	=	3	
26 to 50 percent of time	=	2	(n=5)
51 to 75 percent of time	=	0	mean=26 percent of time
76 to 100 percent of time	=	0	

b) answer only some of the Form B questions:

0 to 25 percent of time	=	6	
26 to 50 percent of time	=	4	(n=15)
51 to 75 percent of time	=	2	mean=47 percent of time
76 to 100 percent of time	=	3	

c) answer all of the Form B questions:

0 to 25 percent of time	=	3	
26 to 50 percent of time	=	6	(n=21)
51 to 75 percent of time	=	3	mean=64.9 percent of time
76 to 100 percent of time	=	9	

If the mariner did not answer all Form B questions, what percentage of time did the mariner:

a) refuse to divulge information

0 to 25 percent of time	=	2	(n=4)
26 to 50 percent of time	=	1	mean=30.3 percent of time
51 to 75 percent of time	=	1	

b) forget the information

0 to 25 percent of time	=	1	
26 to 50 percent of time	=	1	(n=14)
51 to 75 percent of time	=	2	mean=83.0 percent of time
76 to 100 percent of time	=	10	

3.10 Rate the following items in regards to:

Type of information (n=19)	Ability to obtain information					Accuracy of Information				
	Never		About half the time		Always	Never		About half the time		Always
a) Individual's activity at time of casualty	0	0	2	9	8	0	0	4	10	5
b) Hours on duty	0	0	5	7	7	0	0	5	10	4
c) Breaks taken	0	2	8	5	4	0	1	8	7	3
d) Contributing factors	0	4	5	7	3	0	3	11	3	2
e) Feelings of fatigue	1	4	5	5	4	2	6	6	2	3
f) Time off in last 30 days	0	1	6	7	5	0	4	6	5	4
g) Normal schedule	0	3	3	5	8	1	1	4	6	6
h) 72-hour work/rest history	0	2	6	6	5	0	4	8	5	2
i) Workload, sleep quality, and fatigue ratings	0	2	6	6	4	1	2	8	6	2
j) Mariner's opinion on fatigue involvement	0	2	3	5	9	1	3	6	5	4

3.11 If you have experienced any difficulties with the items listed above, please provide a list of these difficulties in regards to:

a) Obtaining information:

1.	No difficulties.	1	
2.	Difficulty in remembering the 30-day work or 72-hour sleep/work history	7	
3.	Difficulty in contacting/reaching the mariner.	6	
4.	Mariners appear unwilling to divulge complete and truthful information.	6	(n=32)
5.	Elapsed time between casualty and contact with the mariner was too long.	4	
6.	Mariner forgot the information or event.	3	
7.	Information is difficult to quantify or define (e.g., irregular work schedule, sleep quality)	3	
8.	Lawyer's involvement or interference.	1	
9.	Other	1	

b) Accuracy of information:

1.	No difficulties.	2	
2.	Mariners appear unwilling to divulge complete and truthful information	8	
3.	Mariner forgot the information.	3	
4.	Information is difficult to quantify or define (e.g., irregular work schedule, sleep quality)	2	(n=22)
5.	Elapsed time between casualty and contact with the mariner was too long.	2	
6.	Lawyer's involvement or interference.	2	
7.	Both IO and mariner can induce biases in the questions and answers	2	
8.	Other comments	1	

3.12 In terms of investigating for fatigue, did you feel that Form B was incomplete?

(n=24) 33.3% Yes 66.7% No *If so, what additional information should have been collected?*

1.	Replace some of the checklist-items by open-ended questions	2	
2.	Provide more space for IO's observations and conclusions	1	
3.	Provide better control of accuracy (information collected is too subjective)	1	(n=7)
4.	Add other items that are human factors related.	1	
5.	Incorporate elements of Form B as part of CG 2692.	1	
6.	Improve IO's interviewing techniques rather than the content of Form B.	1	

3.13 Any suggestions for other improvements to Form B?

1.	No changes to suggest.	6	
2.	Change the Form's layout, especially the 30-day work and 72-hour work/rest history.	7	
3.	Replace some of the checklist items by open-ended questions.	2	(n=19)
4.	Ask IOs to evaluate the accuracy of the information obtained.	2	
5.	Other comments	2	

3.14 Overall, what do you think of the 2-step (Form A and Form B) approach to the investigation of Fatigue-related information? (n=23)

Not useful at all	Not very useful	Useful	Very useful	Extremely useful	Mean
2	4	11	6	0	2.9

4. Benefits and Costs Associated with this Project

4.1 List the benefits, if any, to **you** and the **USCG** of participating in this project:

a) Benfits to you:

1. No benefits. 2
2. Increased awareness of the involvement of human factors and/or fatigue in marine casualties..... 11
3. Improved ability to investigate casualties and/or to interview mariners. ..... 8 (n=26)
4. Better knowledge of the effects of fatigue or human factors concepts..... 3
5. Increased frequency of contacts between IOs and the industry. 1
6. Better prepared for hearings because of additional information gathered. 1

b) Benefits to USCG:

1. No benefits. 1
2. More accurate and more reliable statistics (in general and in regards to Human Factors and fatigue)..... 10
3. Improves investigation process and the overall quality of investigations. ..... 7 (n=26)
4. Provides better training to IOs (human factors knowledge and interviewing techniques)..... 2
5. Helps to determine the need for new and/or improved regulations..... 2
6. Increases the frequency of contacts between IOs and the industry. 2
7. Provides a strong basis to improve MSIS..... 1
8. Identifies the difficulties associated with obtaining objective information..... 1

4.2 List the disadvantages, if any, to **you** and the **USCG** of participating in this project:

a) Disadvantages to you:

1. No disadvantages..... 3
2. Time consuming. 11
3. Imposes additional demands and paperwork requirements..... 5
4. Time lost when attempting to contact mariners. ..... 3 (n=27)
5. Time is diverted towards this project rather than towards USCG investigations (backlog of cases). 2
6. Aggravates mariners and companies..... 2
7. Duplicates information already available on other forms 1

b) Disadvantages to USCG:

1.	No disadvantages	2	
2.	Time is diverted towards this project rather than towards USCG investigations.	5	
3.	Time consuming and additional administrative demands to fulfill.	3	(n=18)
4.	Cost effectiveness (money & time spent versus benefits gained by the information collected)	3	
5.	Increases operational cost to USCG (e.g., long-distance call, forms to duplicate).	3	
6.	Interference from lawyers.	1	
7.	Information collected cannot be entered in MSIS	1	

4.3 As of January 1, 1996, the data collection for this project was terminated, and Forms A and B were no longer required to be filled out. Since then, have you incorporated any of the procedures or forms from this project into your routine investigation of new casualties

(n=23) 43.5% Yes 56.5% No

If yes, which elements of the procedures or forms have you been using:

1.	The fatigue elements of the Forms	8	
2.	The human factors elements of the Forms.	3	(N=12)
3.	The interview techniques learned in this project.	1	

If you answered no, indicate why you choose not to use the procedures and forms to the investigation of new casualties:

1.	Redundant with investigation practices used in the past.	4	
2.	IO prefers to use own investigation techniques.	3	(n=10)
3.	Since it is not required by the USCG, there is no incentive to use it	2	
4.	IO did not have the opportunity to use Form B during project.	1	

5. Recommendations for Improvement

5.1 How would you rate the value of this approach (procedures and forms) in regards to:

(n=24)	Poor 1	2	3	4	Excellent 5	Mean
a) investigating Human Factors information	1	3	7	11	2	3.4
b) reporting Human Factors information	1	5	7	10	1	3.2
c) investigating Fatigue-related information	1	2	9	11	1	3.4
d) reporting Fatigue-related information	1	3	8	10	2	3.4

5.2 If this information was collected by all Marine Safety Offices for a period of 1 year, how would you consider the ability of this information to enable you or the USCG to:

(n=24)	Poor 1	2	3	4	Excellent 5	Mean
a) evaluate whether an individual was tired at time of casualty	1	2	7	8	6	3.7
b) identify all the factors contributing to fatigue	1	2	15	5	1	3.1
c) uncover the effects of fatigue on the mariner	1	5	10	6	2	3.1
d) determine if a casualty was fatigue-related or not	1	1	11	8	3	3.5
e) determine to what extent fatigue exists in the maritime industry	2	4	7	9	2	3.2
f) identify fatigue trends in the maritime industry	3	3	6	9	3	3.3
g) enhance the investigation of human factors causes of casualties	1	4	6	8	5	3.5

5.3 Any suggestions for improvements to the investigation and reporting of Human Factors information?

1.	No suggestions	5	
2.	Revise MSIS product sets to gather more reliable and accurate human factors information.	5	
3.	Streamline and consolidate Form A and B.	4	(n=21)
4.	Focus human factors investigation on type of casualties or type of vessels that have been historically human factors related.	2	
5.	Expand training across all MSOs to learn: 1) how to consider and evaluate human factors in investigations and 2) interview techniques	1	
6.	Design a guide to human factors investigation.	1	
7.	Incorporate the questions on human factors and fatigue in CG 2692.	1	
8.	Provide frequent feedback to IOs.	1	
9.	Other comments	1	

5.4 Any suggestions for improvements to the investigation and reporting of Fatigue-related information?

1.	No suggestions	5	
2.	Change the format of some of the items in Form B (30 days - 72-hour history); consolidate Form A and B	3	
3.	Incorporate some of the elements of Form A and B into CG 2692	2	(n=16)
4.	Expand training across all MSOs to learn: 1) how to consider and evaluate human factors in investigations and 2) interview techniques	2	
5.	Examine vessel's log to uncover work hours	1	
6.	Design a guide to human factors investigation.	1	
7.	Other comments	2	

5.5 Any suggestions for improvements to the entire process?

1.	No suggestions	4	
2.	Change the format of some of the items in Form B (30 days - 72-hour history); consolidate Form A and B	6	
3.	Incorporate some of the elements of Form A and B into CG 2692	3	(n=17)
4.	Expand training across all MSOs to learn: 1) how to consider and evaluate human factors in investigations and 2) interview techniques	1	
5.	Provide frequent feedback to IOs.	1	
6.	Incorporate information into MSIS	1	
7.	Design a guide to human factors investigation.	1	

5.6 In your opinion, should this approach for investigating fatigue be expanded to all Marine Safety Office(s) for a longer duration?

(n=24) 20.8% Yes 41.7% No 37.5% Uncertain

Why?

1.	Additional training in human factors or interview techniques is needed.	4	
2.	Time was spent on casualties that did not have any human factors or fatigue involvement.	4	
3.	Doubt that additional information would be uncover by pursuing this project.	4	(n=19)
4.	If results of this pilot study were conclusive, the process (with some modifications) should be implemented.	2	
5.	USCG needs to have a clear goal and direction before implementing this project.	1	
6.	Lawyers interference	1	
7.	Other comments	3	

5.7 In your opinion, should this approach be expanded to cover additional human factors topics?

(n=22) 36.4% Yes 31.8% No 31.8% Uncertain

Why?

1. Expand the investigation to other factors than fatigue (e.g., training, experience, company working policies) 3
2. Doubt that additional information would be uncover by pursuing this project. 3
3. Additional training in human factors or interview techniques is needed. ..... 1 (n=9)
4. Time was spent on casualties that did not have any human factors or fatigue involvement. 1
5. Focus should remain on fatigue as indicated by mariners 1

5.8 Please note anything that you feel is important in regards to this project but has not been addressed by this questionnaire.

1. Enforce work hour limits and/or regulate throughout the maritime industry (e.g., fishing vessels) 4
2. Provide frequent feedback to MSOs via the newsletter 'Marine Investigator' 2
3. Reduce the time span between the casualty and the investigation. ..... 2 (n=12)
4. Modify Form A and B so that the information can be collected 3 to 4 months after the casualty. 2
5. Assign one of the IO to act as project coordinator at each participating MSO. 1
6. IO should be responsible for determining if human factors or fatigue should be pursued in a given marine casualty 1

We recognize the burden that we have imposed on you over the last 6 to 9 months and we would like to thank you and mention that we have appreciated your collaboration and efforts in this project.

Thank you!

Marvin, Mireille, and Anita

APPENDIX E

Analyses to Identify Casualties with a Fatigue Contribution

An important issue in assessing the procedures employed in this study concerns the value of the collected information in identifying casualties in which fatigue was a contributing factor. We utilize two alternative strategies in this project. The first alternative is to define fatigue on the basis of factors identified in the literature. With this alternative, predetermined levels of selected variables could be identified on the basis of empirical and theoretical findings in the literature. The advantage of this approach is the application of an externally developed and validated fatigue criterion. The disadvantage is the lack of adequate empirical findings interrelating the various factors that contribute to fatigue in the maritime environment.

The second alternative is to usev IOs' and mariners' judgment regarding the contribution of fatigue in a given case. The advantage of this approach is the intimate knowledge that the Investigating Officer and/or mariner may have regarding the specific conditions of the casualty, providing some degree of validity to this approach. The disadvantages are the lack of expertise among mariners and IOs concerning the diagnosis of fatigue, as well as the potential biases of over- or under-reporting fatigue cases among these two groups.

We chose to test the value of using IOs' and mariners' judgment as the initial basis for identifying fatigue cases. Several considerations led to this decision. First, as indicated in much of the literature, it is difficult to predict the onset of fatigue, and much of this research relies upon self-reporting of alertness levels.[1] Thus, the mariners' self-reporting of fatigue would be comparable to this class of criteria. Second, given the roles of Investigating Officers as casualty investigators, we saw them as providing a means of offsetting any potential bias toward underreporting of fatigue by the mariners involved in these cases. Third, examination of the relationships between reported fatigue and potential indicators of fatigue would provide a means of empirically assessing the interrelationships within the casualty data set. Finally, analysis of the relationships between reported fatigue and potential indicators of fatigue could, if successful, provide a separate means of defining fatigue that could be applied across all cases with adequately completed investigation reports.

Investigating Officer and mariner identification of fatigue involvement. A subset of 209 casualty cases that had a direct human factors contribution provided the basis upon which fatigue was investigated, reported, and analyzed in this study.[2] Recall that Form B (Fatigue Investigation) was completed only for those cases in which human factors were identified as a contributor to the casualty. Of these 209 cases, 112 fatigue investigation forms were returned to the investigation team. Of the total of 112 returned Form Bs, some were not fully completed, resulting in different sample sizes across various analyses.

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[1] Refer to Sanquist, T.F., Raby, M., Maloney, A.L., & Carvalhais, A.B. (1996). Fatigue and Alertness in Merchant Marine Personnel: A field study of work and sleep patterns. (Draft Report). Seattle, WA: Battelle Seattle Research Center.

Fatigue investigation forms provide two obvious means of classifying casualties having a fatigue contribution or not. Specifically, IOs were to explicitly ask mariners if they thought that fatigue had contributed to a casualty and record the mariner's response. Mariners responded that fatigue was a contributor in 17 (17.3 percent) of 98 cases. In addition, IOs were to report their personal judgment as to whether or not fatigue was a contributor to the casualty.[3] Investigators judged that fatigue was a contributor in 21 (23.1 percent) of 91 cases.

Table E1 compares the 86 casualty cases with a human factors contribution in which judgments about a possible fatigue contribution were provided by both an IO and a mariner. Overall agreement was obtained on 74 of the 86 cases (86 percent). Table E1 also indicates that IOs had a moderately high level of agreement with mariners when the mariner judged that fatigue was a contributor (78.6 percent); however, for those cases judged by IOs to have a fatigue contribution, mariners made the same classification only 55 percent of the time. Clearly, the two groups were applying different criteria in making a fatigue classification, and mariners were less likely to attribute a casualty to fatigue.

Table E1. IO and Mariner Judgment Regarding the Contribution of Fatigue to Marine Casualties

		IOs' Judgment					
		Fatigue		**Non-Fatigue**		**Totals**	
Mariners' Judgment	**Fatigue**	11	(12.8%)	3	(3.5%)	**14**	**(16.3%)**
	Non-Fatigue	9	(10.5%)	63	(73.3%)	**72**	**(83.7%)**
	Totals	**20**	**(23.3%)**	**66**	**(76.7%)**	**86**	**(100%)**

Reports from IOs help to interpret these differences between the groups. Many mariners were very forthcoming in providing information concerning the working conditions. However, others interpreted the fatigue investigation as a means of determining their culpability in the casualty. In such cases, IOs reported that mariners were often either unwilling to provide information or tended to present working conditions as somewhat better than they appeared to IOs. Additionally, in such cases, mariners were quite unlikely to identify their own case as having a fatigue contribution. This indicates an overall bias towards underreporting fatigue and related factors among the mariners.

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[2] It should be noted that, for the initial steps in the following analyses, the small subset of noncritical vessel casualties with a direct human factors contribution were included in the number to maximize the sample of fatigue cases.

[3] The request for IO judgment regarding fatigue was implemented following the one-month evaluation, so this information was not requested for all casualty cases.

Determination of objective fatigue indicators. Following our selected strategy, we first reviewed individual cases in our casualty database to identify reasonable indicators of fatigue. For these analyses, a casualty was judged to have a fatigue contribution if *either* the Investigation Officer *or* the mariner judged fatigue to be a contributor. These analyses identified a number of factors that had statistically significant relationships between the level of the variable and the judgment of fatigue as a contributor to the casualty.[4] These potential factors were (in order of the strength of their relationship to judged contribution of fatigue):

(1) The number of hours worked by the mariner in the 24 hours preceding the casualty (Worked–24 Hours)

(2) The number of fatigue symptoms recalled by the mariner as occurring prior to the casualty (Fatigue Symptoms)

(3) The mariner's rated level of fatigue for the period prior to the casualty (Fatigue–Day 0)

(4) The number of hours slept by the mariner in the 24 hours preceding the casualty (Slept–24 Hours)

(5) The number of hours worked by the mariner in the 48 hours preceding the casualty (Worked–48 Hours)

(6) The number of environmental stressors recalled by the mariner as being present in the period prior to the casualty (Environmental Stressors)

The set of six potential fatigue indicators were included in a series of *regression analyses.* The regression analyses were conducted to develop a linear combination of variables that could best explain the relationship between the combined values of these variables and the determination (by either the IO or the mariner) that fatigue was or was not a contributor to the casualty across the 61 cases that had information on all of these factors. The resulting equation included only three factors, since the other three factors were highly correlated with these three factors. Equation 1 provides the final *Fatigue Index Equation* in its raw-score form that can be used to calculate a predicted index of fatigue for each of the cases with the available data. In the Fatigue Index Equation, the weights of the three factors relative to one another are what is important. The specific weights were determined to provide a distribution of scores that approximated specified parameters. In addition, a constant of 39.75 was added to provide a mid-point of 50 for the distribution of scores. This value was convenient to establish a cut-off point for classifying cases as to whether or not they were likely to have a fatigue contribution.

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[4] Throughout the present discussion, the terms *statistically significant* and *significant* are used interchangeably; in all cases, this means that a statistical test has been conducted and it has been determined that the reported effect or relationship would occur no more than 5 percent of the time on the basis of random sampling of cases.

Fatigue Index Score = [4.39 * (Fatigue Symptoms)] + [1.25 * (Worked–24 Hours)] - [0.93 * (Slept–24 Hours)] + 39.75.

Equation 1. Raw score values used in computing a Fatigue Index Score for a casualty case.

A Fatigue Index score was computed for the 93 cases with data available for the three factors included in the equation. A subset of 81 of these cases also had a judgment made by either the IO or the mariner regarding the contribution of fatigue to the casualty under investigation. The distribution of the Fatigue Index scores, along with the judgment regarding fatigue, was reviewed and a cut-off score of 50 was selected; thus any case with a Fatigue Index score greater than 50 was classified as a casualty with a fatigue contribution. Table E2 summarizes the agreement between (a) IOs and mariners and (b) the Fatigue Index score and cut-off score of 50 as a basis for classifying casualties as having a fatigue contribution. Across the 81 cases, 65 cases (80 percent of the total) agreed. The 18 cases classified as having a fatigue contribution by both methods represents 69 percent of all "fatigue" cases classified by IOs or mariners and 69 percent of all "fatigue" cases classified using the Fatigue Index method.

Table E2. Classification of Fatigue Contribution in Casualties

		Fatigue Index Classification					
		Fatigue		Not Fatigue		Totals	
IO and Mariner Judgment	Fatigue	18	(22%)	8	(10%)	26	(32%)
	Not Fatigue	8	(10%)	47	(58%)	55	(68%)
	Totals	26	(32%)	55	(68%)	81	(100%)

Figure E1 presents the distribution of Fatigue Index scores, identifying those cases that had an IO or mariner judgment as fatigue-related; as well as those cases that were not related to fatigue by either an IO or mariner, but had the necessary data available to compute a Fatigue Index score. Across the full set of 93 casualty cases that could be classified using the Fatigue Index procedure, 30 of these (32 percent) had a Fatigue Index score greater than 50, resulting in the classification of having a fatigue contribution in the casualty. It should be recalled that this set of 93 cases includes only those identified as having a human factors contribution. Based on the Fatigue Index score and available casualty reports that were adequately completed, estimates of the prevalence of fatigue contribution can be calculated as the product of the

human factors and fatigue rates. The estimated level of fatigue contribution is 23 percent for all casualty cases studied, 16 percent for critical vessel casualties and 33 percent for personnel injuries.[5]

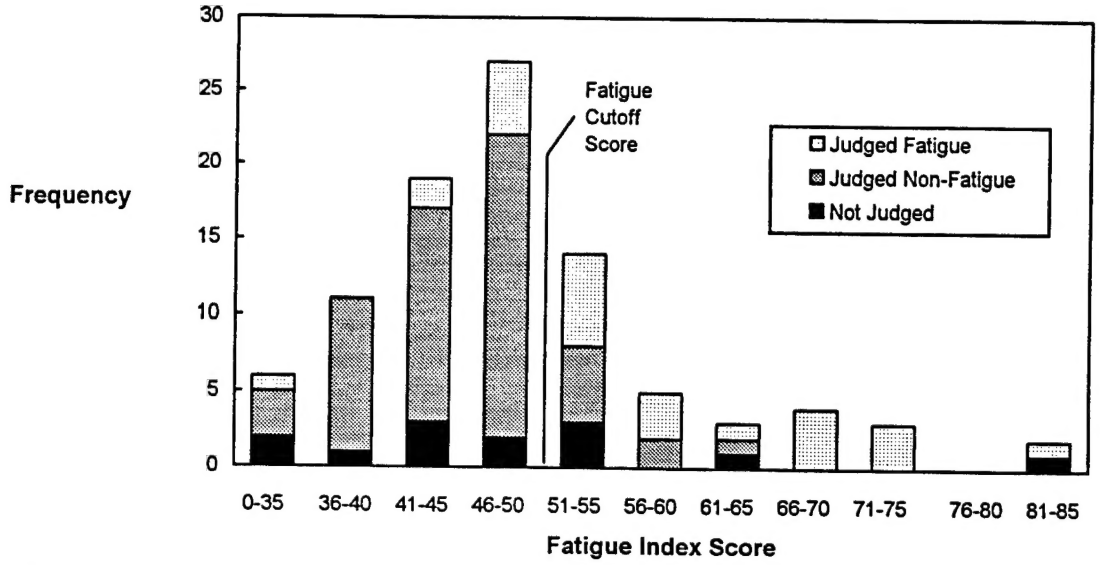

Figure E1. Distribution of Fatigue Index scores for cases judged by an Investigation Officer or mariner, plus those without any judgment by an IO or mariner.

The above values were compared with current rates of USCG-identified fatigue rates using MINMOD cases for CY 93. MINMOD identified fatigue as a contributor in 1.2 percent of the marine casualties and 1.3 percent of the personnel injury cases, substantially different than the results of the present study.

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[5] Across all casualty cases, the estimated level of fatigue contribution is 71 percent * 32 percent = 23 percent. Within critical vessel casualties, the estimated rate of fatigue contribution is 53 percent * 30 percent = 16 percent; and for personnel injuries, the estimated fatigue rate is 91 percent * 36 percent = 33 percent.

APPENDIX F

Selected Analysis Tables

Table F1. Summary of Relationship Between Fatigue Classification Using Fatigue Index and Other Factors

Contributor Variable	Analysis	Type of Casualty: Critical Vessel		Personnel		All Human Factors	
Individual Experience in Years	t-test	ns	(33)	ns	(49)	ns	(81)
Individual Years on Vessel	t-test	ns	(31)	ns	(46)	ns	(77)
Days on Present Schedule	t-test	ns	(9)	ns	(9)	ns	(17)
Days on Tour	t-test	•	(39)	ns	(51)	ns	(88)
Consecutive Days Worked	t-test	*	(31)	ns	(34)	ns	(65)
Number of Days Off in Past 30	t-test	*	(32)	ns	(43)	*	(75)
Hours on Duty	t-test	***	(40)	***	(53)	***	(91)
Hours Before Last Break	t-test	•	(12)	•	(21)	*	(32)
Hours Slept—Prior 24 Hours	t-test	ns	(40)	ns	(53)	ns	(91)
Hours Slept—Prior 48 Hours	t-test	ns	(40)	ns	(53)	ns	(91)
Hours Slept—Prior 72 Hours	t-test	ns	(40)	ns	(53)	ns	(91)
Hours Worked—Prior 24 Hours	t-test	***	(40)	***	(53)	***	(91)
Hours Worked—Prior 48 Hours	t-test	***	(40)	***	(53)	***	(91)
Hours Worked—Prior 72 Hours	t-test	***	(40)	***	(53)	***	(91)
Break Taken	chi-square	•	(39)	ns	(51)	ns	(88)
Change in Schedule	chi-square	*	(40)	ns	(52)	***	(90)
Company/Union Work Limits	chi-square	*	(39)	•	(51)	***	(85)

• p<.10

* p<.05

** p<.01

*** p<.001

( ) = number of casualties

This table summarizes analyses that were performed to evaluate the role of potential contributors to fatigue. Each test compared values of a contributor variable in cases classified as either fatigue-related or not fatigue-related. In this table, a fatigue index score (see Appendix E) was computed to determine whether or not a casualty case was fatigue-related. For each contributor variable, these statistical tests (either t-test or chi-square) were performed, one for each of the three population subsets (i.e., critical vessel, personnel injury, and human factors cases).

Table F2. Summary of Relationship Between Fatigue Classification by IO or Mariner and Other Factors

Contributor Variable	Analysis	Type of Casualty: Critical Vessel		Personnel		All Human Factors	
Individual Experience in Years	t-test	ns	(33)	ns	(50)	ns	(81)
Individual Years on Vessel	t-test	ns	(32)	ns	(46)	ns	(77)
Days on Present Schedule	t-test	ns	(10)	ns	(9)	ns	(18)
Days on Tour	t-test	ns	(37)	ns	(50)	ns	(86)
Consecutive Days Worked	t-test	*	(31)	ns	(31)	ns	(59)
Number of Days Off in Past 30	t-test	•	(28)	ns	(43)	*	(72)
Hours on Duty	t-test	***	(36)	***	(52)	***	(87)
Hours Before Last Break	t-test	ns	(10)	ns	(21)	ns	(30)
Hours Slept—Prior 24 Hours	t-test	ns	(34)	ns	(47)	*	(80)
Hours Slept—Prior 48 Hours	t-test	ns	(34)	ns	(47)	*	(80)
Hours Slept—Prior 72 Hours	t-test	ns	(34)	ns	(47)	•	(80)
Hours Worked—Prior 24 Hours	t-test	***	(34)	**	(47)	***	(80)
Hours Worked—Prior 48 Hours	t-test	**	(34)	ns	(47)	**	(80)
Hours Worked—Prior 72 Hours	t-test	*	(33)	ns	(47)	•	(80)
Break Taken	chi-square	ns	(36)	ns	(50)	ns	(85)
Change in Schedule	chi-square	•	(37)	ns	(51)	**	(87)
Company/Union Work Limits	chi-square	ns	(36)	ns	(50)	ns	(83)

- • p<.10
- * p<.05
- ** p<.01
- *** p<.001

( ) = number of casualties

This table summarizes analyses similar to the ones presented in table F1. The main difference is in the way fatigue cases were classified. In this table, the IO or mariner's judgment was used in assessing whether or not it was fatigue-related, as opposed to using a calculated fatigue index score as in table F1.